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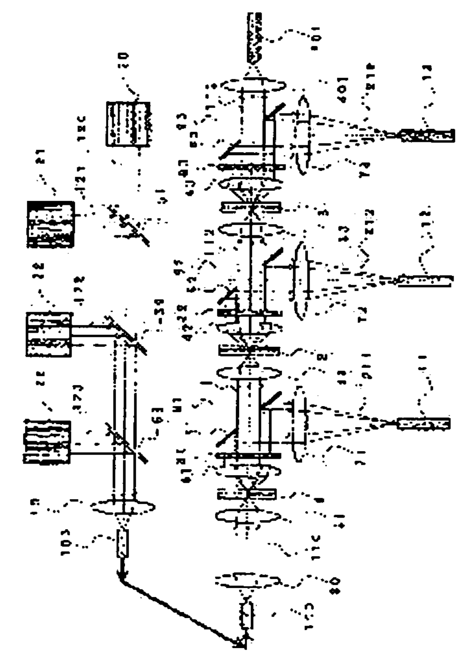
(54) OPTICAL CONTROL SYSTEM OPTICAL PATH SWITCHING TYPE LIGHT SIGNAL TRANSMISSION APPARATUS AND METHOD FOR SWITCHING LIGHT SIGNAL OPTICAL PATH

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical control system optical path switching type light signal transmission apparatus operating at high speed and having high durability and no polarization dependence and to provide a method for switching light signal optical paths.
SOLUTION: In the method for switching a light signal optical paths, disposition of heat lens forming elements 1, 2 and 3 each comprising at least a light absorption layer membrane is so adjusted that at least control light beams 121, 122 and 123 are focused in the respective light absorption layer membranes when the light absorption layer films are convergently irradiated with the control light beams 121, 122 and 123 having wavelengths selected from wavelength bands which are absorbed by the light absorption layer membranes and different from each other and signal light beams 110, 111 and 112 having a single wavelength selected from wavelength bands which is not absorbed by the light absorption layer membranes and the optical path is changed by using the heat lenses based on the distribution of refractive indices reversibly generated and caused by temperature increase generated in the regions where the light absorption layer membranes absorb the control light beams 121, 122 and 123 and their peripheral regions.



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CLAIMS

[Claim(s)]
[Claim 1]
The signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which irradiates the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
By using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly Two or more heat lens formation components which are made to carry out adjustable [of the aperture include angle of signal light], and carry out outgoing radiation or it carries out outgoing radiation according to the existence of an exposure of the control light of one kind of said specific wavelength, with said signal light completed which it converged,
The mirror to which an optical path is changed by making said hole pass the signal light which is the mirror which has the hole of each of said heat lens formation component prepared back respectively, and a reflective means, and carried out outgoing radiation of said heat lens formation component according to the existence of an exposure of the control light of one kind of said specific wavelength, or making it reflect with said reflective means,
Optical controlling expression optical-path change mold lightwave signal transmission equipment characterized by preparation ******.
[Claim 2]
The signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which irradiates the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
It has 2 or more sets of optical-path change devices which consist of combination of the mirror which has a heat lens formation component and a hole,
Said heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, outgoing radiation of said signal light which it converged is carried out at the usual aperture include angle. Outgoing radiation is carried out at an aperture include angle with said signal light larger when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane which it converged than the usual aperture include angle. It is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said

specific wavelength change,
When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, the mirror which has said hole said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or the hole which passes either of the signal light which made said aperture include angle change with a light-receiving lens, When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane, said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or optical controlling expression optical-path change mold lightwave signal transmission equipment which is the mirror which it has [mirror] a reflective means to reflect either of the signal light which made said aperture include angle change, and makes an optical path change with said light-receiving lens.
[Claim 3]
The signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which irradiates the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
It has 2 or more sets of optical-path change devices which consist of combination of the mirror which has a heat lens formation component and a hole,
Said heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly Outgoing radiation is carried out while it had converged said signal light which it converged, when the control light of one kind of said specific wavelength was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane. When control light is not irradiated and a heat lens is not formed, said signal light which it converged is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out at the usual aperture include angle, and outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
The hole which passes said signal light which carries out outgoing radiation from said heat lens formation component while it had converged the mirror which has said hole, when the control light of one kind of said specific wavelength was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane, and which it converged, When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or optical controlling expression optical-path change mold lightwave signal transmission equipment which is the mirror which it has [mirror] a reflective means to reflect either of the signal light which made the light-receiving lens prepared in order to make said aperture include angle change penetrate, and makes an optical path change.
[Claim 4]
The signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which controls the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
One or more sets of 1st optical-path change devices which consist of combination with the mirror which has the 1st heat lens formation component and 1st hole,
It has 1 or more sets of 2nd optical-path change devices which consist of combination with the mirror which has the 2nd heat lens formation component and 2nd hole,
The 1st heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer

membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, outgoing radiation of said signal light which it converged is carried out at the usual aperture include angle. Outgoing radiation is carried out at an aperture include angle with said signal light larger when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane which it converged than the usual aperture include angle. It is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, the mirror which has the 1st hole said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or the hole which passes either of the signal light which made said aperture include angle change with a light-receiving lens, When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane, said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or it is the mirror which it has [mirror] a reflective means to reflect either of the signal light which made said aperture include angle change, and makes an optical path change with said light-receiving lens,
The 2nd heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly Outgoing radiation is carried out while it had converged said signal light which it converged, when control light was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane. When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which it converged is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out at the usual aperture include angle, and outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the outgoing radiation side of said light absorption layer membrane, the mirror which has the 2nd hole The hole which passes said signal light which carries out outgoing radiation from said heat lens formation component while it had converged, and which it converged, When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or optical controlling expression optical-path change mold lightwave signal transmission equipment which is the mirror which it has [mirror] a reflective means to reflect either of the signal light which made the light-receiving lens prepared in order to make said aperture include angle change penetrate, and makes an optical path change.
[Claim 5]
Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 2 with which said 2 or more sets of optical-path change devices are characterized by connecting with the serial through direct or optical-fiber coupled systems through space.
[Claim 6]
Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 3 with which said 2 or more sets of optical-path change devices are characterized by connecting with the serial through direct or optical-fiber coupled systems through space.
[Claim 7]
Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 4 with which said 2 or more sets of optical-path change devices are characterized by connecting with the serial through direct or optical-fiber coupled systems through space.
[Claim 8]
Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 2 characterized by for said 3 or more sets of optical-path change devices branching to the 2-way of the direction which goes straight on through the hole of said mirror through direct or optical-fiber coupled

systems through space for every step of connection, and the direction to reflect, and connecting them with multistage.

[Claim 9]

Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 3 characterized by for said 3 or more sets of optical-path change devices branching to the 2-way of the direction which goes straight on through the hole of said mirror through direct or optical-fiber coupled systems through space for every step of connection, and the direction to reflect, and connecting them with multistage.

[Claim 10]

Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 4 characterized by for said 3 or more sets of optical-path change devices branching to the 2-way of the direction which goes straight on through the hole of said mirror through direct or optical-fiber coupled systems through space for every step of connection, and the direction to reflect, and connecting them with multistage.

[Claim 11]

Signal light of one or more kinds of wavelength and control light of two or more kinds of different wavelength from said signal light are substantially advanced in the same axle and this direction,

Said signal light penetrates, completes said control light and said signal light as each of two or more light absorption layer membranes which absorb respectively only one kind of specific wavelength of said control light alternatively respectively, and irradiates it,

In each of two or more heat lens formation components containing said light absorption layer membrane By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed the control light of one kind of said specific wavelength, and its boundary region, and produces reversibly Outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength, with said signal light completed which it converged, or adjustable [of the aperture include angle of signal light] is carried out, and it carries out outgoing radiation,

The lightwave signal optical-path change approach characterized by making an optical path change by carrying out passage rectilinear propagation of the signal light which carried out outgoing radiation from said heat lens formation component from said hole according to the existence of an exposure of the control light of one kind of said specific wavelength using the mirror with a hole which has a reflector, or making it reflect in a reflector.

[Claim 12]

Signal light of one or more kinds of wavelength and control light of two or more kinds of different wavelength from said signal light are substantially advanced in the same axle and this direction,

Said signal light penetrates, completes said control light and said signal light as each of two or more light absorption layer membranes which absorb respectively only one kind of specific wavelength of said control light alternatively respectively, and irradiates it,

In each of two or more heat lens formation components containing said light absorption layer membrane By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed the control light of one kind of said specific wavelength, and its boundary region, and produces reversibly When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed near the plane of incidence of said light absorption layer membrane, outgoing radiation of said signal light which it converged is carried out from said heat lens formation component at the usual aperture include angle. Outgoing radiation is carried out from said heat lens formation component at an aperture include angle with said signal light larger when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed which it converged than the usual aperture include angle. The aperture include angle of said signal light by which outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength is made to change.

When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, the hole of a mirror with a hole is passed and either of the signal light which made said aperture include angle change said signal light which carries out outgoing radiation with remaining as it is or a light-receiving lens is made to go straight on from said heat lens formation component at the usual aperture include angle.

On the other hand, when the control light of one kind of said specific wavelength is irradiated and a heat

lens is formed near the plane of incidence of said light absorption layer membrane Said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or the lightwave signal optical-path change approach characterized by making an optical path change by reflecting either of the signal light which made said aperture include angle change using the reflector of said mirror with a hole with a light-receiving lens.

[Claim 13]

Signal light of one or more kinds of wavelength and control light of two or more kinds of different wavelength from said signal light are substantially advanced in the same axle and this direction,

Said signal light penetrates, completes said control light and said signal light as each of two or more light absorption layer membranes which absorb respectively only one kind of specific wavelength of said control light alternatively respectively, and irradiates it,

In each of two or more heat lens formation components containing said light absorption layer membrane By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed the control light of one kind of said specific wavelength, and its boundary region, and produces reversibly When the control light of one kind of said specific wavelength was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane, while it had converged said signal light which it converged, outgoing radiation is carried out from said heat lens formation component. When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which it converged makes the aperture include angle of said signal light by which outgoing radiation is carried out from said heat lens formation component at the usual aperture include angle, and outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change.

When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the outgoing radiation side of said light absorption layer membrane, the hole of a mirror with a hole is passed and said signal light which carries out outgoing radiation and which it converged is made to go straight on from said heat lens formation component, while it had converged.

When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, on the other hand, the optical path of said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or the lightwave signal optical-path change approach characterized by making an optical path change by reflecting either of the signal light which made said aperture include angle change using the reflector of said mirror with a hole with a light-receiving lens.

[Claim 14]

Make light of long wave length into signal light most among the light of two or more wavelength, and light of two or more wavelength shorter than signal light is made into control light. The optical-path change device in which the wavelength which the heat lens formation component in said optical-path change device absorbs is the shortest is made into the 1st step. Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 2 characterized by connecting a latter optical-path change device with the order to which each wavelength which the heat lens formation component of said optical-path change device after the 2nd step absorbs becomes long.

[Claim 15]

Make light of long wave length into signal light most among the light of two or more wavelength, and light of two or more wavelength shorter than signal light is made into control light. The optical-path change device in which the wavelength which the heat lens formation component in said optical-path change device absorbs is the shortest is made into the 1st step. Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 3 characterized by connecting a latter optical-path change device with the order to which each wavelength which the heat lens formation component of said optical-path change device after the 2nd step absorbs becomes long.

[Claim 16]

Make light of long wave length into signal light most among the light of two or more wavelength, and light of two or more wavelength shorter than signal light is made into control light. The optical-path change device in which the wavelength which the heat lens formation component in said optical-path change device absorbs is the shortest is made into the 1st step. Optical controlling expression optical-path change mold lightwave signal transmission equipment according to claim 4 characterized by connecting a latter optical-path change device with the order to which each wavelength which the heat lens formation component of

said optical-path change device after the 2nd step absorbs becomes long.

[Translation done.]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
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3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[Field of the Invention]
[0001]
This invention relates to the optical controlling expression optical-path change mold lightwave signal transmission equipment and the lightwave signal optical-path change approach which are used in the optical-communication field and the optical-information-processing field.
[Background of the Invention]
[0002]
Since it corresponds to the explosive increase of the network traffic accompanying the spread of the Internet, and the inside of a firm and domestic intranets, the optical-path transfer device which does not go via an electrical signal (optical switch), i.e., optical - light direct switch, is called for. As an optical fiber, optical waveguide, or the route to which the light which spreads space progresses, i.e., the equipment and the approach which change an optical path For example, the space division mold which changes an optical path between the optical waveguides within optical waveguide, The wavelength division multiplex mold which divides and changes the light of two or more multiplexed wavelength to the optical path according to wavelength, Methods, such as a Time-Division-Multiplexing mold which changes the optical path of the light by which time-division multiplexing was carried out for every fixed time amount, and a free space mold which uses a mirror, a shutter, etc., and divides and compounds spatially the optical path of the light which spreads space, are learned. Multiplexing respectively can also use these methods combining plurality.

[0003]
Although what is made to penetrate the light which has spread waveguide by changing the refractive index of waveguide to a space division mold optical switch by part for what makes the copy of a lightwave signal from the thing and the optical turnout using a directional coupler, and turns light on and off by the gate component, a crossover, or the intersection of Y branch, or is reflected is proposed, it is still a researches-and-developments phase. Although it is said that the thing using the thermooptic effect by electric heater heating is approaching utilization in order to change the refractive index of the waveguide of a Mach-Zehnder-interferometer mold optical waveguide switch, it has the fault that an electrical signal must be used in order that it is not only late, but a speed of response may operate an optical switch with 1 ms extent.
[0004]
A micro electro mechanical system (written as Micro Electro Mechanical System;MEMS), exciton absorption / reflective switch (written as an Exciton Absorption Reflection Switch;EARS switch), the multistage beam shifter mold optical switch, the hologram mold optical switch, the liquid crystal switch, etc. are considered by the free space mold optical switch. These have technical problems, like that the amount of mechanical moving part is and there is a polarization dependency, and cannot say that it is still in a practical use phase enough.
[0005]
Permeability change and refractive-index change which are caused to an optical element by irradiating light on the other hand are used, and research of the all-optical optical element which modulates luminous intensity and a frequency with light, or an optical control system is done briskly directly. this invention persons have studied the optical control system using the organic nano particle light-and-heat lens formation component (nonpatent literature 1 reference) which distributed organic-coloring-matter floc to the polymer matrix aiming at development of the new information processing technique by an all-optical optical element etc. By the method which modulates signal light (780nm) by current and control light (633nm), it is

characterized by carrying out the same axle and parfocal incidence of control light and the signal light, the component of the principle of operation that signal light is refracted with the heat lens transitionally formed of the control absorption of light is developed, and the high-speed response for about 20 nanoseconds is attained. It is the optical control approach of irradiating control light at the optical element which consists of an optical responsibility constituent, and performing said signal luminous-intensity modulation and/or luminous-density modulation which penetrate said optical element when control light changes reversibly the permeability and/or refractive index of signal light in a different wavelength band. Complete respectively said control light and said signal light, and it irradiates to said optical element. and The field where the photon density near each focus (beam waist) of said control light and said signal light is the highest sets in said optical element. The optical control approach characterized by adjusting the optical path of said control light and said signal light so that it may overlap mutually is indicated (from the patent reference 1 to patent reference 7 reference). The control light and signal light from which wavelength differs mutually in the optical element which consists of an optical responsibility constituent are irradiated. The wavelength of said control light shall be chosen from the wavelength band which said optical responsibility constituent absorbs. The heat lens based on distribution of the consistency change resulting from the temperature rise which said optical responsibility constituent generates in the field which absorbed said control light, and its boundary region is made to form reversibly. The optical control approach of performing the signal luminous-intensity modulation and/or luminous-density modulation which penetrate said heat lens is indicated (patent reference 8 reference). And for example, coloring matter / resin film, and the coloring matter solution film are used as the above-mentioned optical element, and the power 2 of control light thru/or the response time of the signal light to the control light exposure in 25mW are indicated to be less than 2 microseconds (patent reference 8 reference).

[0006]

The optical-refraction effectiveness which functions like [the distribution to which temperature distribution arise when the molecule which absorbed light in a part for the core of light absorption with the thermal lensing effect here changes light into heat and this heat spreads around, consequently the refractive index of a light-transmission medium changes spherically towards the exterior from a light absorption core, and a refractive index becomes high towards / the refractive index based on light absorption is low, and / the exterior is produced, and] a concave lens in this is shown. The thermal lensing effect is used in the field of spectral analysis for many years, and super-high sensitivity spectral analysis which also detects the light absorption by one molecule is also possible in current (nonpatent literature 2 and nonpatent literature 3 reference).

[0007]

As a method which deflects an optical path using the refractive-index change by the thermal lensing effect thru/or heat, heat is given to a medium by the exoergic resistor, refractive-index distribution is produced in a medium, and the approach of deflecting light is indicated (patent reference 9 reference). However, since above-mentioned technique will be made to generate heat by the exoergic resistor and a medium will be heated by heat conduction, it has a problem of "the flare of heat" essentially. That is, it is difficult to be unable to give a detailed heat gradient within a large area, but to acquire desired refractive-index distribution by the flare of heat. Furthermore, even if micro processing of an exoergic resistor adopts the photolithography technique used with the semiconductor integrated circuit, it has an actually fixed limitation and a component cannot but enlarge it. if a component is enlarged, in connection with it, optical system is also complicated -- and it enlarges. Moreover, since it will be made to generate heat by the exoergic resistor and a medium will be heated by heat conduction, it has the fault that a response is slow and cannot raise the frequency of refractive-index change, as an essential problem.

[0008]

Moreover, intensity-distribution adjustment devices for irradiating light by wedge-shaped optical intensity distribution are consisted of at least by the optical element which consists of an optical response constituent, and this optical element, refractive-index distribution is formed into said optical element by control light, and the deviation component using the optical element characterized by deflecting signal light of the wavelength which differs from said control light according to this refractive-index distribution is indicated (patent reference 10 reference). Although this method is excellent in the point which controls light by light, it has constraint of less than 30 degrees in a deflecting angle, and has the problem that the optical-path change direction cannot be set up freely.

[0009]

Then, in order that this invention persons may offer the optical-path transfer device with little attenuation on

the strength [optical] in which multiply-connected use is possible and the optical-path change approach of signal light which can be set up freely for the include angle and direction of an optical-path change without a polarization dependency, The control light of the wavelength chosen as the light absorption layer membrane in the heat lens formation component which contains a light absorption layer membrane at least from the wavelength band which said light absorption layer membrane absorbs, And make it converge respectively and the signal light of the wavelength chosen from the wavelength band which said light absorption layer membrane does not absorb is irradiated. Arrangement is adjusted so that said control light may connect a focus in said light absorption layer membrane at least. By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed said control light, and its boundary region, and produces reversibly The condition that said signal light which it converged carries out outgoing radiation from said heat lens formation component at the usual aperture include angle when control light is not irradiated and a heat lens is not formed, The condition of carrying out outgoing radiation from said heat lens formation component at an aperture include angle with said signal light larger when control light is irradiated and a heat lens is formed which it converged than the usual aperture include angle When it is made to realize by making it correspond to the existence of an exposure of said control light, control light is not irradiated and a heat lens is not formed Said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or after making said usual aperture include angle change with a light-receiving lens, it is made to go straight on through the hole of a mirror in which the hole through which said signal light passes was established. When control light is irradiated and a heat lens is formed, on the other hand, said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or after making the aperture include angle of said flare change with a light-receiving lens, it applied for the optical-path change approach of making an optical path changing, by reflecting using said mirror with a hole (patent reference 11 reference).

[0010]

[Patent reference 1] JP,8-286220,A
[Patent reference 2] JP,8-320535,A
[Patent reference 3] JP,8-320536,A
[Patent reference 4] JP,9-329816,A
[Patent reference 5] JP,10-90733,A
[Patent reference 6] JP,10-90734,A
[Patent reference 7] JP,10-148852,A
[Patent reference 8] JP,10-148853,A
[Patent reference 9] JP,60-14221,A
[Patent reference 10] JP,11-194373,A
[Patent reference 11] Application for patent No. 275713 [2002 to]
[Nonpatent literature 1] Yoshitaka Taira, Norio Tanaka, Kikuko Hayamizu, Tetsuro Moriya work, creation, structure evaluation and the optical physical properties of a coloring matter meeting object and floc, the "Electrotechnical Laboratory ****", the Ministry of International Trade and Industry Electrotechnical Laboratory, Agency of Industrial Science and Technology issue, the 59th volume, No. 2, 29 - 49 pages (1994)
[Nonpatent literature 2] The application to the Fujiwara ******, Keiichiro Fuwa, Takayoshi Kobayashi work, a laser induction thermal lensing effect, and its colorimetric method, "chemistry", the Kagaku-Dojin issue, the 36th volume, No. 6, 432 - 438 pages (1981)
[Nonpatent literature 3] Takehiko Kitamori, the Sawada ******, a light-and-heat conversion spectral-analysis method, a "**** weir", the Japan Society for Analytical Chemistry issue, the March, 1994 issue, 178 - 187 pages

[Description of the Invention]

[Problem(s) to be Solved by the Invention]

[0011]

This invention aims at offering the optical controlling expression optical-path change mold lightwave signal transmission equipment and the lightwave signal optical-path change approach which do not have failure, without using a part for an electrical circuit or mechanical moving part and which operate at high speed and do not have a polarization dependency with high endurance.

[Means for Solving the Problem]

[0012]
It is the signal light light source to which the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention irradiates the signal light of one or more kinds of wavelength in order to attain the above-mentioned purpose,
The control light light source which irradiates the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
By using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly Two or more heat lens formation components which are made to carry out adjustable [of the aperture include angle of signal light], and carry out outgoing radiation or it carries out outgoing radiation according to the existence of an exposure of the control light of one kind of said specific wavelength, with said signal light completed which it converged,
It is characterized by to have the mirror to which an optical path is changed by making said hole pass the signal light which is the mirror which has the hole of each of said heat lens formation component prepared back respectively, and a reflective means, and carried out outgoing radiation of said heat lens formation component according to the existence of an exposure of the control light of one kind of said specific wavelength, or making it reflect with said reflective means.
[0013]
Moreover, other optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention is the signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which irradiates the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
It has 2 or more sets of optical-path change devices which consist of combination of the mirror which has a heat lens formation component and a hole,
Said heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, outgoing radiation of said signal light which it converged is carried out at the usual aperture include angle. Outgoing radiation is carried out at an aperture include angle with said signal light larger when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane which it converged than the usual aperture include angle. It is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, the mirror which has said hole said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or the hole which passes either of the signal light which made said aperture include angle change with a light-receiving lens, When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane, said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or it is characterized by being the mirror which it has [mirror] a reflective means to reflect either of the signal light which made said aperture include angle change, and makes an optical path change with said light-receiving lens.

[0014]
Moreover, other optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention is the signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which irradiates the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
It has 2 or more sets of optical-path change devices which consist of combination of the mirror which has a heat lens formation component and a hole,
Said heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly Outgoing radiation is carried out while it had converged said signal light which it converged, when the control light of one kind of said specific wavelength was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane. When control light is not irradiated and a heat lens is not formed, said signal light which it converged is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out at the usual aperture include angle, and outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
The hole which passes said signal light which carries out outgoing radiation from said heat lens formation component while it had converged the mirror which has said hole, when the control light of one kind of said specific wavelength was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane, and which it converged, When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or it is characterized by being the mirror which it has [mirror] a reflective means to reflect either of the signal light which made the light-receiving lens prepared in order to make said aperture include angle change penetrate, and makes an optical path change.
[0015]
Moreover, other optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention is the signal light light source which irradiates the signal light of one or more kinds of wavelength,
The control light light source which controls the control light of two or more kinds of different wavelength from said signal light,
Said signal light is two or more light absorption layer membranes which penetrate and absorb respectively only one kind of specific wavelength of said control light alternatively,
A means to make converge said control light and said signal light on each of said light absorption layer membranes respectively, and to irradiate it,
One or more sets of 1st optical-path change devices which consist of combination with the mirror which has the 1st heat lens formation component and 1st hole,
It has 1 or more sets of 2nd optical-path change devices which consist of combination with the mirror which has the 2nd heat lens formation component and 2nd hole,
The 1st heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, outgoing radiation of said signal light which it converged is carried out at the usual aperture include angle. Outgoing radiation is carried out at an aperture include angle with said signal light larger when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane which it converged than the usual aperture include angle. It is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing

radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, the mirror which has the 1st hole said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or the hole which passes either of the signal light which made said aperture include angle change with a light-receiving lens, When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane, said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or it is the mirror which it has [mirror] a reflective means to reflect either of the signal light which made said aperture include angle change, and makes an optical path change with said light-receiving lens,
The 2nd heat lens formation component by using the heat lens based on distribution of the refractive index which originates in the temperature rise which happens to the field where said light absorption layer membrane absorbed the control light of one kind of said specific wavelength, and its boundary region including said light absorption layer membrane, and is produced reversibly Outgoing radiation is carried out while it had converged said signal light which it converged, when control light was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane. When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which it converged is the heat lens formation component which makes the aperture include angle of said signal light by which outgoing radiation is carried out at the usual aperture include angle, and outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change,
When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the outgoing radiation side of said light absorption layer membrane, the mirror which has the 2nd hole The hole which passes said signal light which carries out outgoing radiation from said heat lens formation component while it had converged, and which it converged, When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which carries out outgoing radiation from said heat lens formation component at the usual aperture include angle as it is Or optical controlling expression optical-path change mold lightwave signal transmission equipment which is the mirror which it has [mirror] a reflective means to reflect either of the signal light which made the light-receiving lens prepared in order to make said aperture include angle change penetrate, and makes an optical path change.
[0016]
Moreover, as for other optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, 2 or more sets of above-mentioned optical-path change devices are characterized by connecting with the serial through direct or optical-fiber coupled systems through space.
[0017]
Moreover, 3 or more sets of above-mentioned optical-path change devices branch to the 2-way of the direction which goes straight on through the hole of said mirror through direct or optical-fiber coupled systems through space for every step of connection, and the direction to reflect, and other optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention is characterized by connecting with multistage.
[0018]
Moreover, the lightwave signal optical-path change approach of this invention,
Signal light of one or more kinds of wavelength and control light of two or more kinds of different wavelength from said signal light are substantially advanced in the same axle and this direction,
Said signal light penetrates, completes said control light and said signal light as each of two or more light absorption layer membranes which absorb respectively only one kind of specific wavelength of said control light alternatively respectively, and irradiates it,
In each of two or more heat lens formation components containing said light absorption layer membrane By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed the control light of one kind of said specific wavelength, and its boundary region, and produces reversibly Outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength, with said signal light completed which it converged, or adjustable [of the aperture include angle of signal light]

is carried out, and it carries out outgoing radiation,
It is characterized by making an optical path change by carrying out passage rectilinear propagation of the signal light which carried out outgoing radiation from said heat lens formation component from said hole according to the existence of an exposure of the control light of one kind of said specific wavelength using the mirror with a hole which has a reflector, or making it reflect in a reflector.
[0019]
Moreover, other lightwave signal optical-path change approaches of this invention,
Signal light of one or more kinds of wavelength and control light of two or more kinds of different wavelength from said signal light are substantially advanced in the same axle and this direction,
Said signal light penetrates, completes said control light and said signal light as each of two or more light absorption layer membranes which absorb respectively only one kind of specific wavelength of said control light alternatively respectively, and irradiates it,
In each of two or more heat lens formation components containing said light absorption layer membrane By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed the control light of one kind of said specific wavelength, and its boundary region, and produces reversibly When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed near the plane of incidence of said light absorption layer membrane, outgoing radiation of said signal light which it converged is carried out from said heat lens formation component at the usual aperture include angle. Outgoing radiation is carried out from said heat lens formation component at an aperture include angle with said signal light larger when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed which it converged than the usual aperture include angle. The aperture include angle of said signal light by which outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength is made to change.
When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, the hole of a mirror with a hole is passed and either of the signal light which made said aperture include angle change said signal light which carries out outgoing radiation with remaining as it is or a light-receiving lens is made to go straight on from said heat lens formation component at the usual aperture include angle.
On the other hand, when the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the plane of incidence of said light absorption layer membrane Said signal light which carries out outgoing radiation while spreading from said heat lens formation component at a larger aperture include angle than usual as it is Or it is characterized by making an optical path change by reflecting either of the signal light which made said aperture include angle change using the reflector of said mirror with a hole with a light-receiving lens.
[0020]
Moreover, other lightwave signal optical-path change approaches of this invention,
Signal light of one or more kinds of wavelength and control light of two or more kinds of different wavelength from said signal light are substantially advanced in the same axle and this direction,
Said signal light penetrates, completes said control light and said signal light as each of two or more light absorption layer membranes which absorb respectively only one kind of specific wavelength of said control light alternatively respectively, and irradiates it,
In each of two or more heat lens formation components containing said light absorption layer membrane By using the heat lens based on distribution of the refractive index which said light absorption layer membrane originates in the temperature rise which happens to the field which absorbed the control light of one kind of said specific wavelength, and its boundary region, and produces reversibly When the control light of one kind of said specific wavelength was irradiated and a heat lens was formed near the outgoing radiation side of said light absorption layer membrane, while it had converged said signal light which it converged, outgoing radiation is carried out from said heat lens formation component. When the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, said signal light which it converged makes the aperture include angle of said signal light by which outgoing radiation is carried out from said heat lens formation component at the usual aperture include angle, and outgoing radiation is carried out according to the existence of an exposure of the control light of one kind of said specific wavelength change.
When the control light of one kind of said specific wavelength is irradiated and a heat lens is formed near the outgoing radiation side of said light absorption layer membrane, the hole of a mirror with a hole is

passed and said signal light which carries out outgoing radiation and which it converged is made to go straight on from said heat lens formation component, while it had converged.
On the other hand, when the control light of one kind of said specific wavelength is not irradiated and a heat lens is not formed, it is characterized by making an optical path change by reflecting either of the signal light which made said aperture include angle change the optical path of said signal light which carries out outgoing radiation with remaining as it is or a light-receiving lens using the reflector of said mirror with a hole from said heat lens formation component at the usual aperture include angle.
[0021]
Moreover, other optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention,
Make light of long wave length into signal light most among the light of two or more wavelength, and light of two or more wavelength shorter than signal light is made into control light. The optical-path change device in which the wavelength which the heat lens formation component in said optical-path change device absorbs is the shortest is made into the 1st step, and it is characterized by connecting a latter optical-path change device with the order to which each wavelength which the heat lens formation component of said optical-path change device after the 2nd step absorbs becomes long.
[Effect of the Invention]
[0022]
By this invention, it can operate at high speed, without using a part for an electrical circuit or mechanical moving part, and optical controlling expression optical-path change mold lightwave signal transmission equipment and the lightwave signal optical-path change approach without a polarization dependency with high endurance can be offered.
[Best Mode of Carrying Out the Invention]
[0023]
[Heat-lens formation component]
In this invention, what has for example, laminating membrane type structure as a heat lens formation component can be used suitably, and if it considers as the configuration of the cascade screen, the following combination can be mentioned.
[0024]
(1) A light absorption layer membrane independent. However, light absorption layer membranes may be any of the laminating mold thin film of "light absorption film" independent monolayer, the two-layer structure of "the light absorption film / heat lens formative layer", or the three-tiered structure "the light absorption film / heat lens formative layer / light absorption film" literally. In addition, the following "light absorption layer membranes" of (2) to (10) shall include the same structure as the above.
[0025]
(2) A light absorption layer membrane / incubation layer membrane
[0026]
(3) An incubation layer membrane / light absorption layer membrane / incubation layer membrane
[0027]
(4) A light absorption layer membrane / heat transfer layer membrane
[0028]
(5) A heat transfer layer membrane / light absorption layer membrane / heat transfer layer membrane
[0029]
(6) A light absorption layer membrane / incubation layer membrane / heat transfer layer membrane
[0030]
(7) A heat transfer layer membrane / light absorption layer membrane / incubation layer membrane
[0031]
(8) A heat transfer layer membrane / light absorption layer membrane / incubation layer membrane / heat transfer layer membrane
[0032]
(9) A heat transfer layer membrane / incubation layer membrane / light absorption layer membrane / incubation layer membrane
[0033]
(10) A heat transfer layer membrane / incubation layer membrane / light absorption layer membrane / incubation layer membrane / heat transfer layer membrane
[0034]

(11) A gradient index lens / (light transmission layer/) above (1) thru/or (10) heat lens formation components
[0035]
(12) A gradient index lens / (light transmission layer/) above (1) thru/or (10) heat lens formation components / (light transmission layer/) gradient index lenses
[0036]
In addition, it means preparing a light transmission layer if needed in above-mentioned "" (light transmission layer/). Furthermore, an antireflection film (AR coat film) may be prepared in the plane of incidence and the outgoing radiation side of light if needed.
[0037]
The sectional view which illustrated an example of a heat lens formation component configuration is shown in drawing 11 . The laminating of the heat lens formation component 500 is carried out to the order of gradient index lens 507 / light transmission layer 506 / heat transfer layer membrane 501 / light absorption layer membrane 503 / heat lens formative layer 505 / light absorption layer membrane 504 / heat transfer layer membrane 502, and it consists of an incidence side of the control light 509 and the signal light 508, for example so that it may illustrate to drawing 11 . In addition, the beam of light of the control light 509 shown in drawing 11 is typical, and refraction between class film is omitted.
[0038]
The sectional view which illustrated another example of a heat lens formation component configuration is shown in drawing 12 . The laminating of the heat lens formation component 600 is carried out to the order of heat transfer layer membrane 601 / light absorption layer membrane 603 / heat lens formative layer 605 / light absorption layer membrane 604 / heat transfer layer membrane 602, and it consists of an incidence side of the control light 609 and the signal light 608, for example so that it may illustrate to drawing 12 . In this case, incidence of the control light 609 and the signal light 608 is carried out to the heat lens formation component 600, being condensed with the condenser lens 610 prepared outside. In addition, the beam of light of the control light 609 shown in drawing 12 is typical, and refraction between class film is omitted.
[0039]
Furthermore, the mimetic diagram which illustrated the coloring matter solution restoration type heat lens formation component is shown in drawing 21 again. The coloring matter solution restoration type heat lens formation component 800 is filled up with the coloring matter solution which acts as the heat [a light absorption layer membrane-cum-] lens formative layer from the inlet 807 of the introductory tubing 806 to the coloring matter solution restoration section 808 of the optical cel 809 surrounded by the incidence and the outgoing radiation side glass 801 and 802 which acts as a heat transfer layer membrane, side windshields 803 and 804, and base glass 805, and stops an inlet 807 to it so that it may illustrate to drawing 21 . That is, it is the thing of a simple component configuration called a heat transfer layer membrane / heat [a light absorption layer membrane-cum-] lens formative layer / heat transfer layer membrane.
[0040]
Order is explained later on below about a light absorption layer membrane, the heat lens formative layer, an incubation layer membrane, a heat transfer layer membrane, a light transmission layer and the ingredient of a gradient index lens, the creation approach, each thickness, etc.
[0041]
In addition, in the range which does not cause trouble to the function, the light absorption layer membrane and the heat lens formative layer which are used by this invention, an incubation layer membrane, a heat transfer layer membrane, a light transmission layer, and the ingredient of a gradient index lens may contain an anti-oxidant well-known as an additive, an ultraviolet ray absorbent, a singlet oxygen quencher, a distributed assistant, etc. in order to raise workability or to raise stability and endurance as an optical element.
[0042]
[The ingredient of a light absorption layer membrane]
Well-known various things can be used as an ingredient of light absorption nature used for the light absorption layer membrane in the heat lens formation component used by this invention.
[0043]
If the example of the light absorption nature ingredient used for the light absorption layer membrane in the heat lens formation component used by this invention is given concretely For example, GaAs, GaAsP, GaAlAs, InP, InSb, The single crystal of compound semiconductors, such as InAs, PbTe, InGaAsP, and ZnSe, What distributed the particle of said compound semiconductor into the matrix material, the metal

halogenide which doped dissimilar metal ion (For example, single crystals, such as a potassium bromide and a sodium chloride), said metal halogenide What distributed (for example, particles, such as a copper bromide, a copper chloride, and a cobalt chloride) into the matrix material, CdS, CdSe, CdSeS which doped dissimilar metal ion, such as copper, What distributed the single crystal of cadmium chalcogenide, such as CdSeTe, and the particle of said cadmium chalcogenide in the matrix material, Semi-conductor single crystal thin films, such as silicon, germanium, a selenium, and a tellurium, What distributed semi-conductor particles, such as a polycrystal thin film thru/or a porosity thin film, silicon, germanium, a selenium, and a tellurium, into the matrix material, A ruby, alexandrite, a garnet, Nd:YAG, sapphire, Ti : The single crystal equivalent to the jewel which doped metal ions, such as sapphire and Nd:YLF, (the so-called laser crystal), The lithium niobate which doped the metal ion (for example, iron ion) (LiNbO3), Ferroelectric crystals, such as LiB 3O5, LiTaO3 and KTiOPO4, KH2PO4, and KNbO3, BaB 2O2, The quartz glass which doped metal ions (for example, neodium ion, erbium ion, etc.), The thing which dissolved or distributed coloring matter, and amorphous coloring matter floc can be suitably used into a matrix material besides being soda glass, borosilicate glass, other glass, etc.

[0044]

Since a matrix material and the selection range of coloring matter are wide and processing to a heat lens formation component is also easy the range, what dissolved or distributed coloring matter in the matrix material also in these can be used especially suitably.

[0045]

As an example of the coloring matter which can be used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach For example, xanthene dyes, such as Rhodamine B, rhodamine 6G, eosine, and Phloxine B, Acridine dyes, such as an acridine orange and acridine red, ethyl red, Azo dye, such as Methyl Red, porphyrin system coloring matter, phthalocyanine system coloring matter, Naphthalocyanine system coloring matter, 3, and 3'-diethyl thia carbocyanine iodide, Cyanine dye, such as 3 and 3'-diethyl OKISA dicarbocyanine iodide, Thoria reel methane system coloring matter, such as ethyl violet and Victoria blue R, naphthoquinone system coloring matter, anthraquinone system coloring matter, naphthalene tetracarboxylic acid diimide system coloring matter, perylene tetracarboxylic acid diimide system coloring matter, etc. can be used suitably.

[0046]

By the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach, it is independent about these coloring matter, or two or more sorts can be mixed and used.

[0047]

The matrix material which can be used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach,

(1) Permeability is high in the wavelength field of the light used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach,

(2) The coloring matter or the various particles which are used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention and the lightwave signal optical-path change approach can be dissolved or distributed with sufficient stability,

The thing of arbitration can be used if the conditions to say are satisfied.

[0048]

The low-melting-glass ingredient created as an inorganic system solid-state-like matrix material with the so-called sol gel process besides being the single crystal of a metal halogenide, the single crystal of a metallic oxide, the single crystal of metal chalcogenide, quartz glass, soda glass, borosilicate glass, etc., for example can be used.

[0049]

As an inorganic system liquid-like matrix material, water, water glass (thick water solution of an alkali silicate), a hydrochloric acid, a sulfuric acid, a nitric acid, an aqua regia, a chlorosulfonic acid, methansulfonic acid, trifluoro methansulfonic acid, etc. can be used.

[0050]

Moreover, various organic solvents can be used as an organic system liquid-like matrix material. As an organic solvent, specifically A methanol, ethanol, isopropyl alcohol, Alcohols, such as n-butanol, amyl

alcohol, a cyclohexanol, and benzyl alcohol, Polyhydric alcohol, such as ethylene glycol, a diethylene glycol, and a glycerol Ester, such as ethyl acetate, n-butyl acetate, amyl acetate, and isopropyl acetate Ketones, such as an acetone, a methyl ethyl ketone, methyl isobutyl ketone, and a cyclohexanone Diethylether, dibutyl ether, methoxy ethanol, ethoxy ethanol, Ether, such as butoxy ethanol and carbitol, a tetrahydrofuran, Cyclic ether, such as 1, 4-dioxane, 1, and 3-dioxolane Dichloromethane, chloroform, a carbon tetrachloride, 1, 2-dichloroethane, 1, 1, 2-trichloroethane, trichlene, bromoform, dibromomethane, Halogenated hydrocarbon, such as diiodomethane, benzene, toluene, A xylene, a chlorobenzene, o-dichlorobenzene, a nitrobenzene, Aromatic hydrocarbon, such as an anisole and alpha-chloronaphthalene, n pentane, Aliphatic hydrocarbon, such as n-hexane, n-heptane, and a cyclohexane Amides, such as N.N-dimethylformamide, N,N-dimethylacetamide, and hexamethylphosphoric triamide Urea derivatives, such as cyclic amide [, such as N-methyl pyrrolidone], tetramethylurea, 1, and 3-dimethyl-2-imidazolidinone Carbonates, such as sulfoxides, such as dimethyl sulfoxide, ethylene carbonate, and propylene carbonate Nitril, such as an acetonitrile, propionitrile, and a benzonitrile Nitrogen-containing heterocyclic compounds, such as a pyridine and a quinoline, triethylamine, Solvents, such as nitromethane besides organic acids, such as amines, such as triethanolamine, diethylamino alcohol, and an aniline, chloroacetic acid, trichloroacetic acid, trifluoroacetic acid, and an acetic acid, a carbon disulfide, and a sulfolane, can be used. The thing of two or more classes may be mixed and used for these solvents again.

[0051]

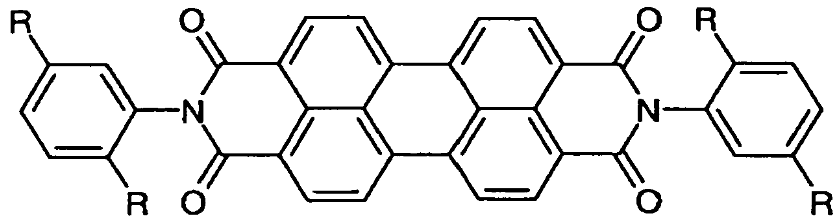
furthermore -- as the matrix material of an organic system -- the shape of liquid and a solid-state -- the organic polymeric materials of the shape of vitrified or rubber can be used. As the example, polystyrene, Pori (alpha methyl styrene), The poly indene, Pori (4-methyl-1-pentene), polyvinyl pyridine, A polyvinyl formal, a polyvinyl acetal, a polyvinyl butyral, Polyvinyl acetate, polyvinyl alcohol, a polyvinyl chloride, a polyvinylidene chloride, Polyvinyl methyl ether, polyvinyl ethyl ether, polyvinyl benzyl ether, A polyvinyl methyl ketone, Pori (N-vinylcarbazole), poly(N-vinylpyrrolidone), Polymethylacrylate, polyacrylic acid ethyl, polyacrylic acid, a polyacrylonitrile, A polymethyl methacrylate, polymethacrylic acid ethyl, polymethacrylic acid butyl, Polymethacrylic acid benzyl, polymethacrylic acid cyclohexyl, polymethacrylic acid, A polymethacrylic acid amide, the poly methacrylonitrile, the poly acetaldehyde, The poly trichloroacetic aldehyde, polyethylene oxide, polypropylene oxide, Polyethylene terephthalate, polybutylene terephthalate, and polycarbonates (bisphenols + carbonic acid) Pori (diethylene-glycol bisallyl carbonate), 6-nylon, 6 and 6-nylon, 12-nylon, 6, 12-nylon, Pori aspartic-acid ethyl, Polyglutamic acid ethyl, the poly lysine, polyproline, Pori (gamma-benzyl-L-glutamate), Methyl cellulose, ethyl cellulose, benzyl cellulose, hydroxyethyl cellulose, Hydroxypropylcellulose, an acetyl cellulose, cellulose triacetate, Cel low SUTORI butyrate, alkyd resin (phthalic anhydride + glycerol), Fatty-acid modified alkyd resin (fatty-acid + phthalic anhydride + glycerol), an unsaturated polyester resin (maleic-anhydride + phthalic anhydride + propylene glycol), An epoxy resin (bisphenols + epichlorohydrin), polyurethane resin, Organic polysilane, such as resin, such as phenol resin, a urea-resin, melamine resin, xylene resin, a toluene resin, and guanamine resin, and Pori (phenyl methylsilane), the organic poly germane, and these copolymerization and copolycondensation objects are mentioned. Moreover, a carbon disulfide, carbon tetrafluoride, ethylbenzene, perfluoro benzene, a perfluoro cyclohexane, or trimethylchlorosilane can use in usual the high molecular compound which carried out the plasma polymerization of the compound without polymerization nature, and obtained it. Furthermore, what it combines as a copolymerization monomeric unit together as a bridge formation radical, and combined the residue of coloring matter as a polymerization initiation end as a side chain of a monomeric unit can also be used for these organic high molecular compounds as a matrix material. Furthermore, aforementioned coloring matter residue and an aforementioned matrix material may form the chemical bond.

[0052]

An approach well-known for dissolving or distributing coloring matter into these matrix materials can be used. For example, after dissolving coloring matter and a matrix material into a common solvent and mixing, How to form a matrix material, since coloring matter is dissolved or distributed to the raw material solution of the inorganic system matrix material manufactured with the approach of evaporating a solvent and removing, and a sol gel process, Into the monomer of an organic macromolecule system matrix material, a solvent is used if needed. Since coloring matter is dissolved or distributed, this monomer A polymerization thru/or the approach of making carry out a polycondensation and forming a matrix material, After carrying out precipitate which both coloring matter and a thermoplastic organic macromolecule system matrix material trickled coloring matter and the solution which dissolved the organic macromolecule system matrix material into the common solvent into the insoluble solvent, and produced it a ** exception

and drying, the approach of heating and melting processing it etc. can be used suitably. Although it is known that you are made to form the special meeting object which is made to condense a coloring matter molecule and is called "H meeting object", "J meeting object", etc. with devising the combination and the processing approach of coloring matter and a matrix material, the coloring matter molecule in a matrix material may be used on the conditions which form such a state of aggregation or a meeting condition.
[0053]
Moreover, an approach well-known for distributing the aforementioned various particles into these matrix materials can be used. Said particle For example, the solution of a matrix material, Or the method of removing a solvent, after distributing in the solution of the precursor of a matrix material, Since said particle is distributed into the monomer of an organic macromolecule system matrix material if needed, this monomer using a solvent as a precursor of a polymerization thru/or the approach of making carry out a polycondensation and forming a matrix material, and a particle After dissolving or distributing metal salts, such as perchloric acid cadmium and a gold chloride, into an organic macromolecule system matrix material, it processes by hydrogen-sulfide gas. For example, the particle of a cadmium sulfide Or the approach and chemical vapor deposition which deposit a golden particle in a matrix material, respectively, the sputtering method, etc. can be suitably used by heat-treating.
[0054]
When coloring matter can be made to exist as a thin film of an amorphous state with little light scattering (amorphous) independently, the amorphous coloring matter film can also be used as a light absorption layer membrane, without using a matrix material.
[0055]
Moreover, when coloring matter can be made to exist independently as microcrystal floc which does not cause light scattering, the microcrystal floc of coloring matter can also be used as a light absorption layer membrane, without using a matrix material. If it is the magnitude in which the particle diameter of said coloring matter minute crystal compares the wavelength of said signal light with the wavelength of control light , and does not exceed one fifth of the wavelength of the shorter one when the laminating of the coloring matter microcrystal floc as a light absorption layer membrane is carry out to the heat lens formative layers (resin etc.) , heat transfer layer membranes (glass etc.) , and/or incubation layer membranes (resin etc.) and it exists as in the heat lens formation component use by this invention , light scattering will not be cause substantially .
[0056]
[Combination and sequence] of the ingredient of a light absorption layer membrane, the wavelength band of signal light, and the wavelength band of control light
According to the purpose of use, a suitable combination can be selected and used for the ingredient of the light absorption layer membrane used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach, the wavelength band of signal light, and the wavelength band of control light as such combination.
[0057]
What is necessary is to determine the wavelength thru/or the wavelength band of signal light according to the purpose of use, and just to select the combination of the ingredient of the optimal light absorption layer membrane for controlling this, and the wavelength of control light first as a concrete configuration procedure, for example. Or what is necessary is just to select the ingredient of a light absorption layer membrane suitable for this combination, after determining the combination of the wavelength of signal light and control light according to the purpose of use.
[0058]
As an example of such a selection procedure, the case which carries out the optical-path change of this with the control light of two or more visible-ray wavelength bands is illustrated below using near infrared rays oscillated from the semiconductor laser in which a ultra high-speed modulation is possible, such as wavelength of 850nm, 1350nm, or 1550 etc.nm, to G Hertz order as a signal light. The laser of (Continuation CW) oscillation method which can be intermittent with the speed of response below a submillimeter second as the light source of control light can be used suitably. From the short-wavelength side to for example, the semi-conductor [405 445nm purple-blue thru/or blue semiconductor laser and] excitation Nd: What changed the wavelength of 1064nm of an YAG laser into 532nm green by the secondary nonlinear optical element, 635 or 670nm red semiconductor laser and 780 thru/or 800nm near infrared ray laser can be selected, and it can be used suitably. It is an N and N'-screw (2, 5-G tert-

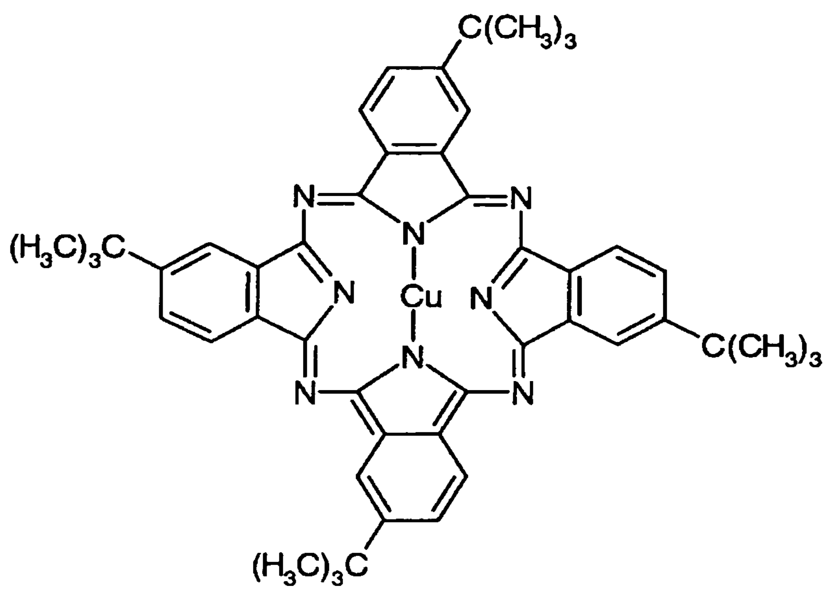
buthylphenyl) as coloring matter which shows absorption to these control light wave length bands, and does not absorb a near infrared ray (850nm thru/or 1550nm). - 3, 4, 9, 10-perylene dicarboxyimide (N, N'-Bis(2, 5-di-tert-butylphenyl)-3, 4 and 9, 10-perylenedicarboxyimide) [1],
[Formula 1]



... [1]

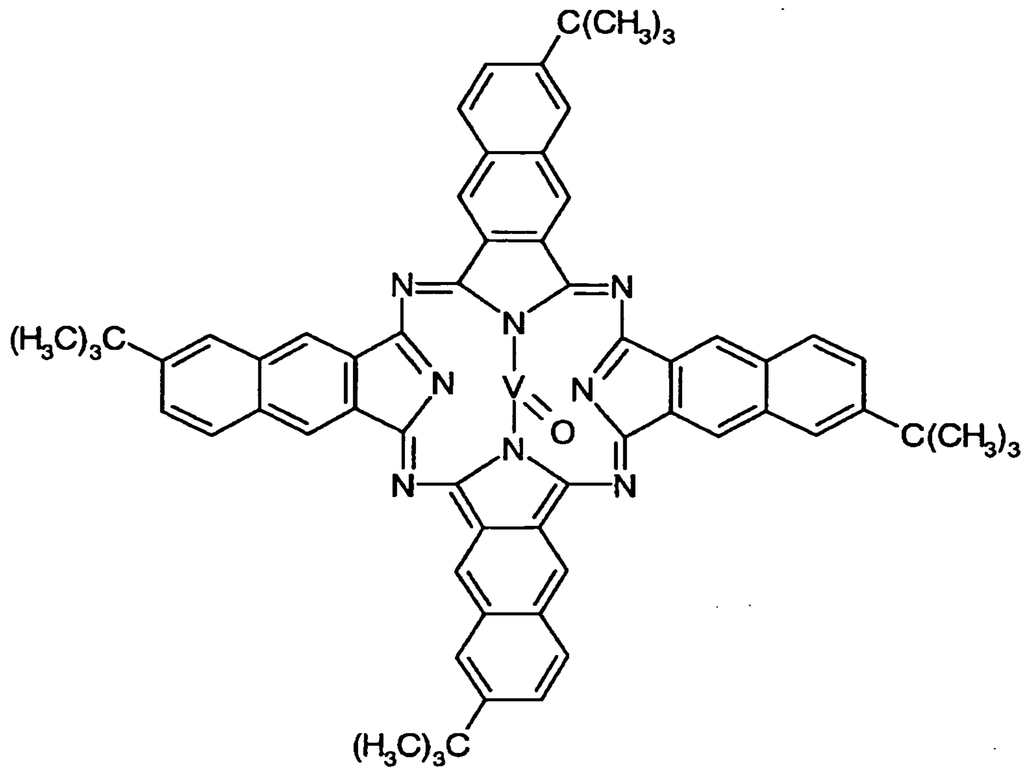
[R = $C(CH_3)_3$]

Copper (II) 2, 9, 16, 23-tetrapod-tert-butyl-29H, and 31H-phthalocyanine (Copper (II) 2, 9, 16, 23-tetra-tert-butyl-29H, 31 H-phthalocyanine) [2],
[Formula 2]



... [2]

Vanadyl 2, 11, and 20, 29-tetra--tert-butyl -2, 3-naphthalocyanine (Vanadyl 2, 11 and 20, 29-tetra-tert-butyl -2, 3-naphthalocyanine) [3],
[Formula 3]



... [3]

Two or more **** can be selected and it can be used suitably respectively. Each of these coloring matter has lightfastness and high thermal resistance, and they are suitable for it in the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach especially as coloring matter for the light absorption layer membranes for heat lens formation. A continuous line, the chain line, and an alternate long and short dash line show respectively the permeability spectrum of the tetrahydrofuran solution of coloring matter [1], [2], and [3] to drawing 22 . Although not shown in drawing 22 , these coloring matter solutions show 98% or more of permeability also in 900 thru/or a 1550nm near infrared ray field.

[0059]

The relation between the oscillation wavelength of said control light laser and the permeability spectrum of these coloring matter is shown in Table 1.

[0060]

[Table 1]

	色素番号	レーザー発振波長 [nm]							
		445	532	635	650	670	780	800	850
透過率 [%]	[1]	3.59	0.10	97.08	97.36	97.33	97.67	97.15	98.64
	[2]	93.64	81.67	2.32	0.78	0.00	97.23	98.37	99.63
	[3]	52.19	89.90	88.72	81.56	73.35	9.06	0.12	89.00

[0061]

As shown in Table 1, coloring matter [1] is suitable as an ingredient of the light absorption layer membrane of a heat lens formation component which absorbs wavelength 445 thru/or 532nm control light, and forms a heat lens. Coloring matter [2] is suitable for the coloring matter [3] as an ingredient of wavelength 635 thru/or the light absorption layer membrane corresponding to 670nm similarly as an ingredient of wavelength 780 thru/or the light absorption layer membrane corresponding to 800nm. It is made to dissolve in said solvent and is filled up with these coloring matter to an optical cel, or it is made to dissolve into

organic polymeric materials, and it is inserted into a heat transfer layer membrane, or it can be used on a heat transfer layer membrane, forming it as the spin coat film or vacuum evaporationo film.

[0062]

When using it, choosing two or more kinds of these coloring matter, it is desirable to use the optical-path change device containing the heat lens formation component corresponding to the absorption wavelength band of each coloring matter, connecting it sequentially from the shorter one of an absorption wavelength band. Namely, by for example, the thing which it is used for coloring matter [1] and the 2nd step in coloring matter [2] or the two-step configuration of [3], and the 1st step, and is used for the optical-path change device of the 1st step as a three-step configuration of coloring matter [3] in coloring matter [1] and the 2nd step at coloring matter [2] and the 3rd step It is possible to use the absorption band region and non-absorption band region of each coloring matter in piles without futility.

[0063]

[Thickness of the presentation of the ingredient of a light absorption layer membrane, and the light absorption layer membrane in a light absorption layer membrane, and thickness of the heat lens formative layer]

In the heat lens formation component used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach a light absorption layer membrane "Light absorption film" independent monolayer, Or you may be any of the laminating mold thin film of the two-layer structure of "the light absorption film / heat lens formative layer", or the three-tiered structure "the light absorption film / heat lens formative layer / light absorption film", and, as for the thickness of the whole light absorption layer membrane, it is desirable not to exceed the twice of the confocal distance of said control light which it converged. Furthermore, when aiming at a much more high-speed speed of response, as for the thickness of a light absorption layer membrane it is thin from said laminating mold thin film, it is desirable not to exceed 1 time of the confocal distance of said control light which it converged.

[0064]

In such conditions, it can set up as such combination on the basis of the permeability of the control light which penetrates a light absorption layer membrane, and signal light about the thickness of the presentation of the ingredient of a light absorption layer membrane used by this invention, and the light absorption film in a light absorption layer membrane (1 or two sheets). For example, the concentration of the component which absorbs control light or signal light at least among the presentations of the ingredient of a light absorption layer membrane can be determined first, and the thickness of the light absorption film in a light absorption layer membrane (1 or two sheets) can be set up so that the permeability of the control light which penetrates a heat lens formation component, and signal light may subsequently become a specific value. Or first, after setting the thickness of the light absorption film in a light absorption layer membrane (1 or two sheets) as a specific value if needed for example, on an equipment design, the presentation of the ingredient of a light absorption layer membrane can be adjusted so that the permeability of the control light which penetrates a heat lens formation component, and signal light may become a specific value.

[0065]

The value of the permeability of the control light which penetrates the light absorption layer membrane optimal in order to pull out magnitude sufficient by the lowest possible optical power and a high-speed thermal lensing effect from the heat lens formation component used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention and the lightwave signal optical-path change approach, and signal light is as being shown below, respectively.

[0066]

In the heat lens formation component used by the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach, performing the concentration of the light absorption component in a light absorption layer membrane and control of an existence condition, and a thickness setup of the light absorption film in a light absorption layer membrane (1 or two sheets) so that the permeability of the control light which spread the light absorption layer membrane in a heat lens formation component may become 90% thru/or 0% be recommended.

[0067]

Performing the concentration of the light absorption component in a light absorption layer membrane and control of an existence condition, and a thickness setup of the light absorption film in a light absorption layer membrane (1 or two sheets) in the condition of not irradiating control light, on the other hand, so that

the permeability of the signal light which spread the light absorption layer membrane in a heat lens formation component may approach to 100% infinite as 10% or more and an upper limit as a minimum be recommend.

[0068]

The minimum of the heat lens formation layer membrane thickness in a light absorption layer membrane is selected according to the ingredient of the heat lens formative layer so that it may indicate below.

[0069]

[The ingredient of the heat lens formative layer in a light absorption layer membrane, and thickness of the heat lens formative layer]

Although the light absorption film of a monolayer itself may be made to act as the heat lens formative layer, the function of light absorption and heat lens formation is made to share with a separate ingredient, and it can also be used, carrying out the laminating of the optimal ingredient chosen respectively.

[0070]

As an ingredient of the heat lens formative layer in a light absorption layer membrane, a liquid, liquid crystal, and a solid ingredient can be used. It is suitable if the heat lens formative layer consists of an amorphous organic compound, an organic compound liquid, and an organic compound chosen from the group which consists of liquid crystal especially. In addition, when the quality of the materials of the heat lens formative layer are liquid crystal and a liquid, the light absorption film and/or a heat transfer layer membrane are created with the quality of the material of self-gestalt holdout, the depletion equivalent to heat lens formation layer thickness can be prepared, and the heat lens formative layer can be created by pouring in the heat lens formative layer ingredient of a flow condition there. What is necessary is on the other hand, to make one side or both sides of the heat lens formative layer carry out the laminating of the light absorption film, and just to create, when the quality of the material of the heat lens formative layer is a solid-state.

[0071]

The quality of the material of the heat lens formative layer may hope that it is not single, may be the cascade screen of two or more kinds of solid-states, and may carry out the laminating of a solid-state and the liquid.

[0072]

Although based also on the class of ingredient to be used, especially if the range of heat lens formation layer thickness is hundreds of micrometers from dozens of nanometers, it is [that what is necessary is just the thickness of the range of 1mm from several nanometers] suitable.

[0073]

As mentioned above, as for the thickness of the sum total of the light absorption layer membrane which comes to carry out the laminating of the heat lens formative layer, 1, or the light absorption film of two sheets, it is desirable not to exceed the twice of the confocal distance of said control light which it converged.

[0074]

Although a liquid, liquid crystal, and a solid ingredient can be used as an ingredient of the heat lens formative layer in a light absorption layer membrane, in any case, an ingredient with the large temperature dependence of a refractive index is desirable.

[0075]

the physical-properties value of the refractive-index temperature dependence of a typical organic compound liquid and water -- reference [-- D. -- it is indicated by Solimini:J.Appl.Phys., vol.37, and 3314(1966)]. The temperature-change [unit of the refractive index to light with a wavelength of 633nm: 1/K] has large alcohol, such as a methanol (3.9x10-4), and its non-hydrogen bond nature organic solvents, such as a cyclopentane (5.7x10-4), benzene (6.4x10-4), chloroform (5.8x10-4), and a carbon disulfide (7.7x10-4), are still larger than water (0.8x10-4).

[0076]

When using liquid crystal as an ingredient of the heat lens formative layer in a light absorption layer membrane, the thing of well-known arbitration can be used as liquid crystal. Specifically Various cholesterol derivatives, a 4'-n-butoxy benzylidene-4-cyano aniline, 4'4, such as -n-hexyl benzylidene-4-cyano aniline,'-alkoxy benzylidene-4-cyano aniline, A 4 '- ethoxy benzylidene-4-n-butyl aniline and 4'-methoxybenzylideneamino azobenzene, 4'-alkoxy benzylidene aniline, such as 4-(4'-methoxy benzylidene) amino biphenyl and 4-(4'-methoxy benzylidene) amino stilbene, A 4'-cyano benzylidene-4-n-BUCHITOKISHI aniline, 4'4, such as - cyano benzylidene-4-n-hexyloxy aniline,'-cyano benzylidene-4-alkoxy aniline, 4'-n-buthoxycarbonyloxy benzylidene-4-methoxyaniline, Carbonates, such as p-

carboxyphenyl and n-amyl carbonate, and n-heptyl, 4-(4'-ethoxy phenoxy carbonyl) phenyl carbonate A 4-n-butyl benzoic acid and 4 '- ethoxy phenyl, 4-n-butyl benzoic-acid, and 4'-octyloxy phenyl, 4-alkyl benzoic acid and 4'-alkoxy phenyl ester, such as a 4-n-pentyl benzoic acid and 4'-hexyloxy phenyl Azoxybenzene derivatives, such as - G n-amyloxy azoxybenzene, and 4 and 4 '4, 4'-G n-nonyloxy azoxybenzene, Liquid crystal, such as a 4-cyano-4'-n-octyl biphenyl and 4-cyano-4'4-cyano-4, such as -n-dodecyl biphenyl,'-alkyl biphenyls, And (2S, 3S) a -3-methyl-2-chloro pentanoic acid and4', a 4"-octyloxy biphenyl, Ferroelectric liquid crystals, such as a 4'-(2-methylbutyl) biphenyl-4-carboxylic acid and 4-hexyloxy phenyl, and a 4'-octyl biphenyl-4-carboxylic acid, 4-(2-methylbutyl) phenyl, can be used.

[0077]

When using a solid ingredient as an ingredient of the heat lens formative layer in a light absorption layer membrane, especially an amorphous organic compound with the big temperature dependence of a refractive index with small light scattering is suitable. Specifically, a thing well-known as resin for optics can be selected and used out of various organic polymeric materials like said matrix material. For Pori (methyl methacrylate), 1.2x10-4 and a polycarbonate are [1.4x10-4 and the polystyrene of the temperature change [unit:1/K] of the refractive index of the resin for optics indicated by reference [edited by TECHNICAL INFORMATION INSTITUTE, "development of the resin for the newest optics, the design of a property and high precision components and forming technique", TECHNICAL INFORMATION INSTITUTE (1993), and P.35]] 1.5x10-4. These resin can be suitably used as an ingredient of the heat lens formative layer in a light absorption layer membrane.

[0078]

While the refractive-index temperature dependence of said organic solvent has the merit of being larger than the case of said resin for optics, the problem of boiling if the temperature rise by control light exposure reaches at the boiling point of an organic solvent has it (it is satisfactory when using the solvent of a high-boiling point). On the other hand, in the case of a polycarbonate, the resin for optics from which the volatile impurity was removed thoroughly is usable also in a severe condition to which the temperature rise by control light exposure exceeds 250 degrees C.

[0079]

[Incubation layer membrane]

When using a gas as an incubation layer membrane, inert gas, such as nitrogen besides air, helium, neon, and an argon, can be used suitably.

[0080]

When using a liquid as an incubation layer membrane, thermal conductivity is equivalent to a light absorption layer membrane, or the liquid of arbitration can be used, if it is the quality of the material smaller than a light absorption layer membrane, and control light and signal light are penetrated and the quality of the material of a light absorption layer membrane is not dissolved or corroded. For example, fluid paraffin can be used when a light absorption layer membrane consists of a polymethyl methacrylate containing cyanine dye.

[0081]

When using a solid-state as an incubation layer membrane, thermal conductivity is equivalent to a light absorption layer membrane (light absorption film and heat lens formative layer), or if it is the quality of the material smaller than a light absorption layer membrane, and control light and signal light are penetrated and it does not react with the quality of the material of a light absorption layer membrane or a heat transfer layer membrane, the solid-state of arbitration can be used. For example, when a light absorption layer membrane consists of a polymethyl methacrylate containing cyanine dye, the polymethyl methacrylate [thermal conductivity 0.15Wm-1K-1 in 300K] which does not contain coloring matter can be used as an incubation layer membrane.

[0082]

[The ingredient of a heat transfer layer membrane]

The thing of arbitration can be used, if the quality of the material with larger thermal conductivity than a light absorption layer membrane is desirable as a heat transfer layer membrane, control light and signal light are penetrated and it does not react with the quality of the material of a light absorption layer membrane or an incubation layer membrane. As the quality of the material with high and thermal conductivity and the small light absorption in the wavelength band of a visible ray For example, a diamond [thermal conductivity 900Wm-1K-1 in 300K], sapphire [-- said 46Wm(s)-1K-1] and a quartz single crystal [c-axis -- parallel -- said 10.4Wm(s)-1K-1] and quartz-glass [-- said 1.38Wm(s)-1K-1] and hard-glass [-- said 1.10Wm(s)-1K-1] etc. can be suitably used as a heat transfer layer membrane.

[0083]
[The ingredient of a light transmission layer]
Although the laminating of the gradient index lens as a convergence means of said control light may be carried out and it may be prepared in the incidence side of said control light through the light transmission layer as shown in drawing 11 , as the quality of the material of a light transmission layer, the same thing as the quality of the material of a solid incubation layer membrane and/or a heat transfer layer membrane can be used for the heat lens formation component used by this invention. A light transmission layer is not only for making said control light and signal light penetrate efficiently but for pasting up a gradient index lens as a heat lens formation component component literally. What has the light transmittance of the wavelength band of said control light and signal light high among the so-called ultraviolet curing mold resin or electron ray hardening mold resin can be used especially suitably.
[0084]
[The creation approach of a heat lens formation component]
The creation approach of the heat lens formation component used by this invention is selected by arbitration according to the class of ingredient which a heat lens formation component constitutes and uses, and a well-known approach can be used for it.
[0085]
For example, in the case of the above single crystals, the ingredient of light absorption nature used for the light absorption film in a heat lens formation component can create the light absorption film by cutting / polish processing of a single crystal.
[0086]
For example, when creating the heat lens formative layer which consists of light absorption film which consists of a matrix material containing coloring matter, and resin for optics, and the heat lens formation component of the configuration of "the heat transfer layer membrane / the light absorption film / heat lens formative layer / light absorption film / heat transfer layer membrane" used combining optical glass as a heat transfer layer membrane, the light absorption film can be first created on a heat transfer layer membrane by approach which are enumerated below.
[0087]
The approach of carrying out coating of the solution which dissolved coloring matter and a matrix material on the glass plate used as a heat transfer layer membrane by coating methods, such as the applying method, the blade coat method, the roll coat method, a spin coat method, a dipping method, and a spray method, or printing by print processes, such as the Taira version, letterpress, an intaglio, a mimeograph, a screen, and an imprint, and forming the light absorption film may be used. In this case, the inorganic system matrix material creation approach by the sol gel process can also be used for formation of the light absorption film.
[0088]
The electrochemical membrane formation technique, such as an electrodeposition process, an electrolytic polymerization method, and a micell electrolytic decomposition process (JP,63-243298,A), can be used.
[0089]
Furthermore, Lang Mia Blodgett's technique which moves the monomolecular film made to form on water can be used.
[0090]
As an approach of using the polymerization thru/or polycondensation reaction of a raw material monomer, when a monomer is a liquid, the casting method, the reaction injection mold method, a plasma polymerization method, a photopolymerization method, etc. are mentioned.
[0091]
Approaches, such as a sublimation replica method, vacuum deposition, vacuum evaporation technique, the ion beam method, the sputtering method, a plasma polymerization method, a CVD method, and organic molecular-beam vacuum deposition, can also be used.
[0092]
Spray into a high vacuum container from the spraying nozzle which prepared the organic system optical material of two or more components for every component in the state of a solution or dispersion liquid, it is made to deposit on a substrate, and the manufacture approach (patent official report No. 2599569) of the compound-die optical thin film characterized by heat-treating can also be used.
[0093]
The above creation approaches of the solid light absorption film can be suitably used, also when creating the incubation layer membrane which consists of solid organic polymeric materials.

[0094]
Subsequently, when creating the heat lens formative layer using the thermoplastic resin for optics, the heat lens formation component of the configuration of "a heat transfer layer membrane / the light absorption film / heat lens formative layer / light absorption film / heat transfer layer membrane" can be created using vacuum hot pressing (JP,4-99609,A). That is, the laminating mold thin film of the above-mentioned configuration can be created by inserting the powder or sheet of the resin for thermoplastic optics by the heat transfer layer membrane (glass plate) of two sheets in which the light absorption film was formed on the front face, and carrying out hot press under a high vacuum by the above-mentioned approach.
[0095]
[The ingredient and the creation approach] of a gradient index lens
Although the laminating of the gradient index lens as a convergence means of said control light may be carried out and it may be prepared in the incidence side of said control light through the light transmission layer, what of arbitration is well-known as the ingredient and the creation approach of this gradient index lens can be used for the heat lens formation component used by this invention.
[0096]
For example, [M. which can create the gradient index lens of a refractive-index distribution pattern with the organic macromolecule system quality of the material using osmosis and the diffusion phenomenon of a monomer Oikawa, KIga, T.Sanada : Jpn.J.Appl.Phys and 20(1) L51-L54(1981)]. That is, with a monomer exchange technique, a refractive-index distribution lens can be made on a flat substrate at a monolithic, for example, the methyl methacrylate (n= 1.494) as low refractive-index plastics is diffused into the flat plastic plate of Pori isophthalic acid JIAKURIRU (n= 1.570) which has a high refractive index from the surroundings of the mask of the circular disk of 3.6mmphi.
[0097]
Moreover, [M. which can use the diffusion phenomenon of inorganic ion and can create the gradient index lens of a refractive-index distribution pattern with the inorganic textile-glass-yarn quality of the material Oikawa, KIga : Appl.Opt. and 21(6)1052-1056(1982)]. That is, in preparing the fenestera rotunda before and behind the diameter of 100 micrometers by the technique of a photolithography, soaking in fused salt, and making refractive-index distribution form according to the ion exchange, after attaching a mask to a glass substrate, the diameter of 0.9mm, the focal distance of 2mm, and the lens of numerical-aperture NA=0.23 can be made to form by impressing electric field over several hours and promoting the ion exchange.
[0098]
[Optical cel]
The optical cel used with a coloring matter solution restoration type heat lens formation component A gestalt is effectually given to the function to hold a coloring matter solution, and a coloring matter solution. The function to have the function to make it act as the heat [a light absorption layer membrane-cum-] lens formative layer, to receive further the signal light and control light which are converged and irradiated, and to make said signal light and said control light spread to said optical responsibility constituent, And after penetrating said optical responsibility constituent, it has the function which is made to spread said signal light to emit and carries out outgoing radiation.
[0099]
The gestalt of the optical cel used with a coloring matter solution restoration type heat lens formation component is divided roughly into an external gestalt and internal morphology.
[0100]
According to the configuration of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, as for the external gestalt of an optical cel, the thing of configurations, such as the shape of the shape of the shape of tabular and a rectangular parallelepiped, cylindrical, a semicircle column, and the square pole and the triangle pole, is used.
[0101]
It is the gestalt of the internal morphology of an optical cel, i.e., the coloring matter solution restoration section, and a gestalt is effectually given to a coloring matter solution. Specifically according to the configuration of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, the internal morphology of an optical cel can be suitably chosen from the shape of the shape of the shape of the shape of the shape of a thin film, a thick film, tabular, and a rectangular parallelepiped, cylindrical, a semicircle column, and the square pole, and the triangle pole, and a convex lens, and a concave lens etc.

[0102]
The thing of arbitration can be used for the configuration and the quality of the material of an optical cel if the following requirements are satisfied.
[0103]
(1) Above external gestalten and internal morphology are maintainable to a precision in a service condition.
[0104]
(2) It is inactive to a coloring matter solution.
[0105]
(3) The presentation change by stripping, transparency, and osmosis of many components which constitute a coloring matter solution can be prevented.
[0106]
(4) A solution can be prevented from coloring matter deteriorating by contacting the gas or liquid which exists in operating environments, such as oxygen and water.
[0107]
As the quality of the material of an optical cel, it cannot be based on the class of coloring matter solution, but, specifically, various optical glass, such as soda glass and borosilicate glass, quartz glass, sapphire, etc. can be used suitably. Moreover, when the solvents of a coloring matter solution are water and an alcoholic system, plastics, such as Pori (methyl methacrylate), polystyrene, and a polycarbonate, can also be used.
[0108]
In addition, what is necessary is to restrict the function to prevent presentation change and degradation of a coloring matter solution among the above-mentioned requirements within the limits of the service life as a heat lens formation component, and just to be able to demonstrate it.
[0109]
The optical cel of the integral construction which built into said optical cel other optical elements used by this invention, i.e., a condenser lens, the light-receiving lens, the wavelength selection transparency filter, etc. can be used.
[0110]
[Count of a beam waist diameter]
in order to use a thermal lensing effect effectively in the optical controlling expression optical path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical path change approach, it be desirable to set up the configuration and magnitude of a beam cross section of said signal light and said control light, respectively so that the beam cross-sectional area of said signal light in the field where the photon density near the focus (condense point) be the highest, i.e., a "beam waist", may not exceed the beam cross-sectional area of said control light in a beam waist.
[0111]
Hereafter, the case where it is the Gaussian beam from which the amplitude distribution of the electric field of a travelling direction beam cross section, i.e., the energy distribution of the flux of light, is Gaussian distribution is described. In addition, although the following explanation explains the case where a condenser lens (gradient index lens) is used as a beam convergence means, it is the same even if convergence means are a concave mirror and a refractive-index distributed lens.
[0112]
The situation of the bundle of rays in about 301 focus when completing the Gaussian beam by aperture angle 2theta with the condenser lenses 31, such as drawing 1, etc. and a wave front 300 is shown in drawing 14 . Here, the location where the diameter of 2omega of the Gaussian beam of wavelength lambda becomes min is called "beam waist." Hereafter, 2omega of beam waist diameters shall be expressed with 0. For a diffraction operation of light, 0 does not become zero but has 2omega of values of finite. In addition, beam-radius omega and the definition of omega 0 are the distance when measuring the location where energy becomes 1 / e2 (e is the bottom of a natural logarithm) on the basis of the energy for a beam core of the Gaussian beam from a beam core, and a beam diameter is expressed with 2omega or 2omega0. Needless to say, at the core of a beam waist, a photon density is the highest.
[0113]
In the case of the Gaussian beam, the beam flare angle theta in a distant place is fully connected with wavelength lambda and the diameter omega 0 of a beam waist by the following formula [4] from a beam waist.
[0114]
(Several 1)

Pi-theta-omega 0 ** lambda -- [4]
Here, pi is a circular constant.
[0115]
The diameter omega 0 of a beam waist condensed with the condenser lens is calculable from the numerical aperture and focal distance of beam-radius omega which restricts when fulfilling the conditions of "being fully a distant place from a beam waist", and carries out incidence to a condenser lens using this formula, and a condenser lens.
[0116]
Furthermore, generally 0 can be expressed with the following formula [5] the beam waist diameter of 2omega at the time of completing the parallel Gaussian beam (wavelength lambda) of beam-radius omega with the condenser lens of the effective opening radius a and a numerical aperture NA.
[0117]
(Several 2)
2omega0 ** K-lambda/NA -- [5]
Here, since it cannot solve algebraically, a multiplier k can be determined by performing numerical-analysis count about the optical intensity distribution in a lens image formation side.
[0118]
If the ratio of the effective opening radius a of beam-radius omega which carries out incidence, and a condenser lens is changed into a condenser lens and numerical-analysis count is performed, the value of the multiplier k of a formula [5] can be found as follows.
[0119]
(Several 3)
A/omega = 1 At the time k ** 0.92
A/omega = 2 At the time k ** 1.3
A/omega = 3 At the time k ** 1.9
A/omega = 4 At the time k ** 3
[0120]
That is, as beam-radius omega is smaller than the effective opening radius a of a condenser lens, the diameter omega 0 of a beam waist becomes larger.
[0121]
For example, when signal light with a wavelength of 780nm is converged using a lens with a numerical aperture [0.25] and an effective opening radius of about 5mm as a condenser lens, if beam-radius omega which carries out incidence to a condenser lens is 5mm, a/omega is about 1, and if 1.4 micrometers and omega of the radius omega 0 of a beam waist are 1.25mm, omega 0 will be calculated for a/omega with 4.7 micrometers by about 4. When control light with a wavelength of 633nm is converged similarly, if beam-radius omega is 5mm, a/omega is about 1, and if 1.2 micrometers and omega of the radius omega 0 of a beam waist are 1.25mm, omega 0 will be calculated for a/omega with 3.8 micrometers by about 4.
[0122]
What is necessary is just to expand a beam diameter until the intensity distribution of the light beam which carries out incidence to a condenser lens become close to a plane wave in order for the photon density near the focus of a condenser lens to make min the cross-sectional area of the light beam in the highest field, i.e., a beam waist, so that clearly from this example of count (beam expanded). Moreover, it also turns out that the diameter of a beam waist becomes small, so that the wavelength of light is short, when the beam diameter which carries out incidence to a condenser lens is the same.
[0123]
As mentioned above, in order to use a thermal lensing effect effectively in the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach, it is desirable to set up the configuration and magnitude of a beam cross section of said signal light and said control light, respectively so that the beam cross-sectional area of said signal light in the field where the photon density near the beam waist is the highest may not exceed the beam cross-sectional area of said control light in a beam waist. If it is the case where signal light and control light use the Gaussian beam, according to the above explanation and a formula, in the state of the collimated beam before converging with convergence means, such as a condenser lens According to wavelength, carry out beam expanded of the beam diameter of signal light and control light if needed, and by adjusting The beam cross-sectional area of said signal light in the field where the photon density near the beam waist is the highest can be prevented from exceeding the beam cross-sectional area of said control light in a beam waist.

The optical system of the Kevlar mold which consists of a well-known thing, for example, two convex lenses, as a beam expanded means can be used.
[0124]
[Count of confocal distance Zc]
Generally, in the case of the Gaussian beam, in the section of confocal distance Zc, it can consider mostly that a convergence beam is parallel light [near the beam waist of the flux of light which it converged with convergence means, such as a convex lens, (i.e., a focus)], and confocal distance Zc can be expressed with the formula [6] which used a circular constant pi, the beam waist radius omega 0, and wavelength lambda.
[0125]
(Several 4)
Zc = piomega02/lambda -- [6]
A formula [7] will be obtained if a formula [5] is substituted for omega 0 of a formula [6].
[0126]
(Several 5)
Zc ** pi(k/NA)2lambda/4 -- [7]
[0127]
For example, when signal light with a wavelength of 780nm is converged using a lens with a numerical aperture [0.25] and an effective opening radius of about 5mm as a condenser lens, if beam-radius omega which carries out incidence to a condenser lens is 5mm, a/omega is about 1, if 8.3 micrometers and omega of 1.4 micrometers and confocal distance Zc are 1.25mm as for the radius omega 0 of a beam waist, by about 4, omega 0 will be calculated with 4.7 micrometers and confocal distance Zc will be calculated for a/omega with 88 micrometers. When control light with a wavelength of 633nm is converged similarly, if beam-radius omega is 5mm, a/omega is about 1, if 6.7 micrometers and omega of 1.2 micrometers and confocal distance Zc are 1.25mm as for the radius omega 0 of a beam waist, by about 4, omega 0 will be calculated with 3.8 micrometers and confocal distance Zc will be calculated for a/omega with 71 micrometers.
[0128]
[Numerical aperture of a condenser lens and a light-receiving lens]
Although it is irradiating so that signal light and control light may be completed with a condenser lens on the same axle and a focus may be connected into a heat lens formation component in the optical controlling expression optical-path change mold lightwave signal transmission equipment of this invention, and the lightwave signal optical-path change approach When receiving the light which carries out outgoing radiation at a larger aperture include angle than usual from a heat lens formation component with a light-receiving lens and collimating in parallel light, it is the numerical aperture (it is hereafter referred to as NA.) of this light-receiving lens. Setting up so that it may become larger than NA of a condenser lens is recommended. Furthermore, NA of a light-receiving lens has the desirable more than twice of NA of a condenser lens. However, when the effective opening radius a of a condenser lens is large (namely, a/omega> 1) from beam-radius omega which carries out incidence to a condenser lens, the substantial numerical aperture of a condenser lens is smaller than the numerical aperture of a condenser lens. Therefore, the numerical aperture of a light-receiving lens is larger than the substantial numerical aperture of a condenser lens instead of condenser lens numerical aperture, and it is desirable to set up more than twice. Even if expanded more than to the twice at the time of the beam diameter of signal light carrying out incidence of the NA of a light-receiving lens to a heat lens formation component by making it into twice [more than] NA of a condenser lens, it becomes possible to receive light without loss.
[0129]
[The optimal thickness of a light absorption layer membrane]
Thickness of 1 which constitutes a light absorption layer membrane, or the light absorption film of two sheets was not changed, but heat lens formation layer thickness was changed, and the sample was produced, and as a result of experimenting about two or more heat lens formation components from which thickness differs by optical-density regularity, when it was made twice the confocal distance Zc calculated as mentioned above into the upper limit of the thickness of a light absorption layer membrane, it turned out that the optical speed of response of a thermal lensing effect becomes a high speed enough.
[0130]
About the minimum of the thickness of a light absorption layer membrane, as long as a thermal lensing effect can be demonstrated, as thin, it is more desirable.
[0131]

[Thickness of an incubation layer membrane]
An optimum value (a lower limit and upper limit) which makes the magnitude and/or the rate of an optical response max exists in the thickness of an incubation layer membrane. The value can be experimentally determined according to the quality of the material of the quality of the material of the configuration of a heat lens formation component, and a light absorption layer membrane and thickness, and an incubation layer membrane, the quality of the material of a heat transfer layer membrane, thickness, etc. As a heat transfer layer membrane, as the quality of the material of usual borosilicate glass, an incubation layer membrane, and the heat lens formative layer For example, a polycarbonate, as the light absorption film -- the vacuum evaporationo film of a platinum phthalocyanine -- using -- glass (a heat transfer layer membrane --) 150 micrometers of thickness, a polycarbonate resin layer (incubation layer) / platinum phthalocyanine vacuum evaporationo film (the light absorption film --) 0.2 micrometers of thickness, a polycarbonate resin layer (heat lens formative layer, 20 micrometers of thickness) / platinum phthalocyanine vacuum evaporationo film (the light absorption film --) When the heat lens formation component of the configuration of 0.2 micrometers of thickness, a polycarbonate resin layer (incubation layer) / glass (a heat transfer layer membrane, 150 micrometers of thickness) is created, preferably, from 5nm, the thickness of an incubation layer membrane is 5 micrometers, and is 50nm to 500nm still more preferably.
[0132]
[Thickness of a heat transfer layer membrane]
An optimum value (in this case, lower limit) which makes the magnitude and/or the rate of an optical response max exists also in the thickness of a heat transfer layer membrane. The value can be experimentally determined according to the quality of the material of the quality of the material of the quality of the material of the configuration of a heat lens formation component, and a light absorption layer membrane and thickness, and an incubation layer and thickness, and a heat transfer layer membrane etc. As a heat transfer layer membrane, as the quality of the material of usual borosilicate glass, an incubation layer membrane, and the heat lens formative layer For example, a polycarbonate, as the light absorption film -- the vacuum evaporationo film of a platinum phthalocyanine -- using -- glass (a heat transfer layer membrane --) 150 micrometers of thickness, a polycarbonate resin layer (incubation layer) / platinum phthalocyanine vacuum evaporationo film (the light absorption film --) 0.2 micrometers of thickness, a polycarbonate resin layer (heat lens formative layer, 20 micrometers of thickness) / platinum phthalocyanine vacuum evaporationo film (the light absorption film --) When the heat lens formation component of the configuration of 0.2 micrometers of thickness, a polycarbonate resin layer (incubation layer) / glass (a heat transfer layer membrane, 150 micrometers of thickness) is created, 10 micrometers of minimums of the thickness of a heat transfer layer membrane are 100 micrometers still more preferably preferably. In addition, although there is nothing, the constraint from the magnitude and/or the rate of the optical response about the upper limit of the thickness of a heat transfer layer membrane needs to make consistency have with the method of the condenser lens used and a light-receiving lens, a focal distance, and the working distance (working distance), and it is necessary to design it.
[Example]
[0133]
Hereafter, the operation gestalt of this invention is explained to a detail, referring to an example.
[0134]
[Example 1]
The outline configuration of the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 1 is shown in drawing 1 a. The optical controlling expression optical-path change mold lightwave signal transmission equipment of drawing 1 a The control light light sources 21, 22, and 23 from which the one signal light light source 20 and signal light 120 differ in wavelength, whose number is three and from which wavelength differs mutually, The dichroic mirrors 51, 52, and 53 for arranging all the opticals axis of the signal light 120 and three control light 121,122,123, and making it spread in this direction on the same axle, The condenser lens 10 for doubling the signal light 120 and three control light 121,122,123, and carrying out incidence to an optical fiber 100, The optical fiber 100 which doubles and transmits the signal light 120 and three control light 121,122,123, The collimate lens 30 for returning substantially the signal light 120 and three control light 121,122,123 which carry out outgoing radiation from an optical fiber 100 to a collimated beam, "A heat lens incident light condenser lens (31, 32, 33), a heat lens formation component (1, 2, 3), The case where the optical-path change devices 91, 92, and 93 which consist of a heat lens outgoing radiation light light-receiving lens (41, 42, 43), a wavelength selection transparency filter (81, 82, 83), and a mirror with a hole (61, 62, 63)" are connected with a three-

step serial is illustrated. It is condensed with the condenser lens 401 of rectilinear-propagation outgoing radiation signal light, and the rectilinear-propagation signal light 111 and 112 which carries out outgoing radiation from the optical-path change devices 91 and 92 carries out incidence of the rectilinear-propagation signal light 113 which is spatially combined and carries out incidence respectively to the heat lens incident light condenser lenses 32 and 33 of the latter optical-path change devices 92 and 93 and which carries out outgoing radiation from the 3rd step of optical-path change device 93 to the optical fiber 101 of rectilinear-propagation outgoing radiation signal light. Moreover, the signal light 211,212,213 which an optical path changes and carries out outgoing radiation is respectively condensed from the optical-path change devices 91, 92, and 93 with the outgoing radiation signal light condenser lenses 71, 72, and 73 after an optical-path change, and incidence is carried out to the outgoing radiation signal light optical fibers 11, 12, and 13 after an optical-path change. The usual single mode auartz optical fibre (die length 10 thru/or 100m) was used as optical fibers 11, 12, and 13,100,101. According to the permeability / transmission-distance property of control light and signal light, it can be used instead of a single mode auartz optical fibre, being able to choose a multimode auartz optical fibre, SI mold plastic optical fiber, GI mold plastic optical fiber, etc.

[0135]

The connectivity number of an optical-path change device corresponds to the number of the signal light light sources with which wavelength differs mutually. However, the number of stages which can be connected from the permeability of the signal light per one step of optical-path change device, the early age strength of the signal light which carries out incidence to optical controlling expression optical-path change mold lightwave signal transmission equipment, and signal light reinforcement required for the last target is calculated. For example, if the permeability per one step of optical-path change device is 85% (0.7dB is decreased as signal strength), the comprehensive permeability in four-step serial connection will become 52.2% (this 2.8dB attenuation).

[0136]

The three-step serial configuration shown in drawing 1 a is hereafter made into an example, and it explains to a detail. In addition, the partial diagrammatic view which added further the partial diagrammatic view which extracted the parts of the condenser lens 31 in drawing 1 a and the heat lens formation component 1 for the light-receiving lens 41, the mirror 61 with a hole, etc. to drawing 7 and drawing 8 is shown in drawing 9 and drawing 10 . Moreover, when you make the optical-path change devices 91, 92, and 93 connect with a space joint mold as it is shown in drawing 1 a, in order to avoid that the block diagram of the equipment which established three or more optical-path change devices becomes complicated, suppose that a part of outline block diagram (left figure of drawing 2 a) of the optical-path change device of a space joint mold is symbolized, and it displays as shown in [in the right figure of drawing 2 a]. That is, for example, the optical controlling expression optical-path change mold lightwave signal transmission equipment of drawing 1 a is displayed with the outline block diagram symbolized in part like drawing 1 b. Except that the notation approaches differ, since drawing 1 a and drawing 1 b are the outline block diagrams of the same contents, when drawing 1 a and drawing 1 b do not need to be distinguished, they decide to only call it "drawing 1" hereafter.

[0137]

Moreover, although two or more optical-path change devices can also be made to connect with an optical-fiber joint mold, suppose that the outline block diagram of the optical-path change device of an optical-fiber joint mold is omitted in this case, and it displays like drawing 3 .

[0138]

In addition, in drawing 1 a thru/or drawing 3 and drawing 7 thru/or drawing 10 , although the heat lens formation component 1 is illustrated as the three-tiered structure "heat transfer layer membrane 501 / light absorption layer membrane 503 / heat transfer layer membrane 502", it is not limited to this.

[0139]

In this example, the coloring matter solution restoration type heat lens formation component 800 (drawing 21) respectively filled up with the solution of the above-mentioned coloring matter [1], [2], and [3] was used as heat lens formation components 1, 2, and 3. o-dichlorobenzene thoroughly dehydrated and deaerated as a solvent in which said coloring matter is dissolved was used. The optical cel 809 set spacing in the thickness of the coloring matter solution restoration section 808, i.e., the interior of incidence and outgoing radiation side glass 801 and 802, to 200 micrometers using the thing of the same configuration about the heat lens formation components 1, 2, and 3. AR coat was given to the external surface of the incidence and the outgoing radiation side glass 801 and 802 of the optical cel 809. Moreover, after performing restoration and degassing processing of a coloring matter solution, melting and the seal of the inlet 807 of the optical

cel 809 were done. The concentration of a coloring matter solution was adjusted between 0.2 thru/or 2 % of the weight, and about coloring matter [1], [2], and [3], respectively, 0.0 thru/or 0.2%, the permeability of 532nm, 670nm, and 800nm adjusted it so that the permeability of 850nm of signal light might become 85 thru/or 99%.

[0140]

this example -- the incidence signal light 110 from an optical fiber 100 -- a collimate lens 30 -- 5.0mm of beam radii -- he is trying to become a parallel ray mostly

[0141]

In this example, as the light source 20 of the signal light 120, although surface-emitting type semiconductor laser with an oscillation wavelength of 850nm which can be modulated by 2.5GHz is used, the oscillation wavelength of 1350nm and the semiconductor laser light in which a 1550nm ultra high-speed modulation is possible may be used. Moreover, the signal light of the wavelength of these plurality may be used for coincidence. In this example, the signal light optical path is respectively changed to the heat lens formation components 1, 2, and 3 by intermittence of control light, using semiconductor laser (the secondary higher harmonic with an oscillation wavelength of 532nm of a semi-conductor excitation Nd:YAG laser, 670nm, and 800nm) as the control light light sources 21, 22, and 23 which irradiate the control light 121,122 and 123 for making a heat lens form respectively. Beam shaping is carried out and the control light 121,122 and 123 uses so that each may become the parallel ray of 4.5mm of beam radii. The laser power of the control light light source may be 2 thru/or 10mW also in which this side of condenser lenses 31, 32, or 33.

[0142]

The control light 121,122 and 123 and the signal light 110,111 and 112 are respectively completed with the common condenser lenses 31, 32, and 33, and it is irradiating to the heat lens formation components 1, 2, and 3, respectively. Before carrying out incidence to an optical fiber 100 so that each beam waists of control light and signal light may overlap mutually in a heat lens formation component, signal light and control light are adjusted so that dichroic mirrors 51, 52, and 53 may be used and the same optical axis, and signal light and control light may become parallel mutually. By doing in this way, it becomes possible to use efficiently for travelling direction modification of signal light the thermal lensing effect formed of the light absorption in a control light beam waist location.

[0143]

Each of said signal light and three control light used that whose optical intensity distribution of a beam cross section are Gaussian distribution. If such a laser light is condensed with a lens, the optical intensity distribution in a beam waist (a condensing point; focus) will turn into Gaussian distribution. The heat lens formation component containing said light absorption film is irradiated through a condenser lens by making into control light laser light of the wavelength band absorbed by the light absorption film, if it is made to converge in the light absorption layer membrane containing the heat lens formative layer, the light absorption film will absorb laser light, the temperature of the heat lens formative layer rises, consequently a refractive index falls. If the light which became Gaussian distribution as mentioned above is irradiated, it converges a part for the core of Gaussian distribution with strong optical reinforcement, and the irradiated place will take "the lead in light absorption", and the temperature of the part will become [a refractive index] the smallest most highly. It functions like [the distribution to which the refractive index of the light absorption layer membrane which contains the heat lens formative layer with the heat which the light absorption turned to a periphery from a part for the core of light absorption changes to heat, and is spread further around changes spherically towards the exterior from a light absorption core, and a refractive index becomes high towards / the refractive index based on light absorption is low, and / the exterior is produced, and] a concave lens in this. That is, the velocity of light in case, as for light, light passes through the place where a part for the core of Gaussian distribution with strong optical reinforcement was irradiated greatly [a rate] therefore in a place smaller than the large place of a refractive index is larger than the velocity of light in case light passes through the place where the circumference part of Gaussian distribution with optical weak reinforcement was irradiated. Therefore, it turns at light in the direction in which the circumference part of Gaussian distribution with optical weak reinforcement was irradiated. Locally, this is the same actuation as the concave lens in the inside of atmospheric air. Since the advancing own flux of light of control light also deforms in fact with the heat lens which control light was irradiated into the light absorption layer membrane which is condensed with a condenser lens 31 etc. and contains the heat lens formative layer, and light absorption happened to multiplex in the travelling direction of convergence light, and was formed in multiplex, the thermal lensing effect observed differs from what is depended on a single concave lens like the after-mentioned.

[0144]
In this example, the signal light which passed the heat lens formation components 1, 2, and 3 is mostly collimated in parallel light with the light-receiving lenses 41, 42, and 43. The numerical aperture (hereafter referred to as "NA".) of this light-receiving lens is set up so that it may become larger than NA of a condenser lens. In NA of a condenser lens, in this example, NA of 0.25 and a light-receiving lens uses 0.55. NA of a light-receiving lens has the desirable more than twice of NA of a condenser lens. If this relation is satisfied, the combination of NA of a condenser lens and a collimate lens will not be restricted to this example. Even if expanded more than to the twice at the time of the beam diameter of signal light carrying out incidence of the NA of a light-receiving lens to a heat lens formation component by making it into twice [more than] NA of a condenser lens, it becomes possible to receive light without loss. In addition, in this example, it presupposed that the focal distance of a condenser lens and a light-receiving lens is the same, and the effective diameter of a condenser lens used about 10mm thing.
[0145]
Incidence of the signal light which collimated with the light-receiving lenses 41, 42, and 43 is carried out to the mirrors 61, 62, and 63 with a hole. It becomes possible to change the optical path of signal light by preparing this mirror with a hole so that it may explain to a detail later.
[0146]
If coincidence is irradiated so that a focus may be connected [in / for the control light of the wavelength in the absorption band region of a light absorption layer membrane, and the signal light which is the wavelength of a transparency band / the location 5 near the plane of incidence of the light absorption layer membrane of the heat lens formation component 1] as shown in drawing 7 (a) With the heat lens 50 formed in the location near plane of incidence of control light as shown in drawing 8 (a), outgoing radiation of the signal light is carried out at the larger aperture include angle as an outgoing radiation light 201 diffused so that a cross section might spread in the shape of a ring than the usual outgoing radiation light 200. Outgoing radiation is carried out as an outgoing radiation light 119 on which it converged signal light with the heat lens 60 formed in the location near an outgoing radiation side of control light as it was shown in drawing 8 (b), when coincidence was irradiated so that a focus may be connected [in / as shown in drawing 7 (b) on the other hand / the location 6 near the outgoing radiation side of the light absorption layer membrane of a heat lens formation component]. If neither of drawing 7 (a) and drawing 7 (b) of the cases irradiates control light, as a dotted line shows, only signal light will carry out outgoing radiation of the signal light to drawing 8 (a) and drawing 8 (b) as an outgoing radiation light 200 of the usual aperture include angle, without being influenced of the heat lenses 50 or 60.
[0147]
In order to investigate such a thermal lensing effect, the difference of the optical intensity distribution in the signal light beam cross section corresponding to the existence of a thermal lensing effect and a difference of a condensing point location was measured. Namely, in the equipment which shows an outline to drawing 1 or drawing 9 , it considers as the numerical aperture 0.55 of the light-receiving lens 41, and the numerical aperture 0.25 of a condenser lens 31. The optical intensity-distribution measuring instrument 700 as shows an outline to drawing 13 instead of the mirror 61 with a hole is installed. All the signal light beams that penetrated the heat lens formation component 1 were received with the light-receiving lens 41, incidence was carried out as a parallel ray to the light sensing portion 701 (effective diameter of 20mm) of said optical intensity-distribution measuring instrument, and the optical intensity distribution of a signal light beam cross section were measured. A measurement result is shown in drawing 18 , drawing 19 , and drawing 20 . As an optical intensity-distribution measuring instrument is shown in drawing 13 , the first slit 702 with a width of face of 1mm is formed to a light sensing portion 701 (effective diameter of 20mm) here. In the die-length direction of the first slit, i.e., drawing 13 , to the sense of a point 710 to the point 720 It is equipment which move the second slit 703 with a width of face of 25 micrometers with constant speed, and the luminous intensity which passed the aperture of the rectangle which is 1mmx25micrometer which the slit of two sheets makes is made to correspond to the migration location of said aperture, and is measured. What is necessary is just to record the output of the detector which received the light which passed said aperture on the storage oscilloscope synchronized with the passing speed of the second slit 703, in order to make it correspond to the migration location of said aperture and to measure optical reinforcement. Drawing 18 - drawing 20 show the optical intensity distribution about the light beam cross section of the signal light recorded on the storage oscilloscope as mentioned above, an axis of abscissa (location in a light beam cross section) corresponds to the location which the core of a light sensing portion 701 was set to 0, the negative direction was defined for the point 710 of drawing 13 , it defined the forward direction and the coordinate

for the point 720, and was expressed, and an axis of ordinate expresses optical reinforcement.
[0148]
Drawing 18 is the optical intensity distribution of said signal light beam cross section when it corresponds in the case of drawing 9 (a), and control light does not carry out incidence to the heat lens formation component 1 but only signal light carries out incidence. The optical intensity distribution in this case are distribution (in general "Gaussian distribution") in which reinforcement becomes weaker as the reinforcement for a core is strong and goes on the outskirts. Therefore, if the mirror 61 with a hole which has the hole 161 of magnitude sufficient in this case is installed like drawing 9 (a), all the signal light beams 111 can pass through the hole 161 of a mirror with a hole. If the beam diameter of the signal light beam 111 made into parallel light here with d1 and the light-receiving lens 41 (focal distance f2) in the beam diameter of the signal light which carries out incidence to a condenser lens 31 (focal distance f1) as an parallel light is set to d2,
(Several 6)
f1: f2=d1:d2 -- [8]
It comes out, and since it is, d2 can be calculated by the following formula.
[0149]
(Several 7)
d2=(f2/f1) xd1 -- [9]
[0150]
By this example 1, the mirror 61 with a hole has the optical axis of signal light, and the include angle of 45 degrees, and is installed. Moreover, the cross section of the signal light which passes through a hole 161 is circular. Therefore, the configuration of a hole 161 needs to be the ellipse of a minor axis D1 and a major axis D2, and D1 and D2 have the relation of the following formula [10].
[0151]
(Several 8)
D2=D1xroot2 -- [10]
[0152]
Here, the minor axis D1 of the ellipse form hole 161 of the mirror 61 with a hole should be just larger than the beam diameter d2 of the signal light beam 111 called for from a formula [9]. However, if D1 is too large, a part of signal light expanded in the shape of a ring by the exposure of control light will pass. That is, it is d1.01 times 2 and 1.2 times the optimum value of D1 of this, and is it more preferably. [of this] [1.02 times thru/or 1.1 times]
[0153]
In this example 1, the focal distance f1 of a condenser lens 31 and the focal distance f2 of the light-receiving lens 41 presupposed that it is the same. Therefore, the beam diameter d2 of the signal light 111 made into parallel light with the beam diameter d1 and light-receiving lens of the signal light 110 which carries out incidence to a condenser lens 31 is the same, and is 10mm as mentioned above. Therefore, 10.1mm thru/or 12mm are desirable, and is 10.2mm thru/or 11mm more preferably, and the minor axis D1 of the ellipse form hole 161 of the mirror 61 with a hole in this example 1 could be 10.5mm in fact. D2 is 14.8mm from a formula [7]. Moreover, the thing of the magnitude (50mm angle) which can 45-degree reflect a beam with a diameter of 30mm was used for the size of a mirror.
[0154]
Drawing 19 is the optical intensity distribution of the signal light beam cross section when setting a focus (condensing point) as the location 5 (incidence side of light) near the condenser lens 31 of the heat lens formation component 1, and irradiating control light. The optical reinforcement for a core of the optical intensity distribution in this case is weak, and they are the distribution to which optical reinforcement increases in the shape of a ring on the outskirts. Zero are approached as the optical reinforcement of the core of a signal light beam cross section decreases depending on the physical relationship of control light reinforcement and the heat lens formation component 1, and a focus and its control light reinforcement increases. Moreover, the maximum location of signal light reinforcement was a bigger value (diameter of about 15mm) than the original beam diameter.
[0155]
Use of the thermal lensing effect corresponding to drawing 20 is indicated in the example 2.
[0156]
As mentioned above, if it collects, in optical arrangement of drawing 8 (a), it corresponds to the existence of a control light exposure. The optical intensity distribution of the beam cross section of the signal light which

passed the heat lens formation component are changed to ring-like distribution of drawing 19 between the Gaussian distribution of drawing 18 (when it is a control **** exposure). (when it is a control light exposure) The change of the optical path of signal light is attained by taking this out separately, respectively by the mirror with a hole which suited the configuration of the optical intensity distribution of a signal light beam cross section.

[0157]

By this example 1, the mirror 61 with a hole has the optical axis of signal light, and the include angle of 45 degrees, and is installed. The mirror side of the mirror 61 with a hole created dielectric multilayers by the sputtering method on the glass side, and what was adjusted so that a reflection factor might become the maximum on the wavelength of signal light was used for it. The ellipse-like hole was leaned 45 degrees to glass, was made in it, and the part of the hole 161 of the mirror 61 with a hole created it on it. It is more desirable to make a hole, since a glass side has several % reflection and attenuation and the cross talk of signal light happen instead of making a hole, although it is not necessary to attach the reflective film in the shape of an ellipse. in order that the inside of a hole may prevent the stray light by light scattering etc., it is smooth and nonreflective processing is carried out -- things are desirable. Moreover, gold, silver, etc. are [that what is necessary is just the ingredient which has reflection in not only dielectric multilayers but the control light to be used, and signal light] sufficient as the reflective film.

[0158]

by optical-path change, as shown in drawing 1, the signal light (switch signal light) 211,212 and 213 which it turned 90 degrees and was taken out from the travelling direction since signal Mitsumoto condenses with condenser lenses 71, 72, and 73, and carries out incidence to optical fibers 11, 12, and 13.

[0159]

the case where all the light sources 21, 22, and 23 of control light have gone out -- signal light -- a thermal lensing effect -- not winning popularity -- the signal light 111,112 -- subsequently outgoing radiation is carried out as 113. The outgoing radiation signal light 113 is condensed with a condenser lens 401, and incidence is carried out to an optical fiber 101.

[0160]

In addition, incidence is carried out to a photodetector etc. instead of optical fibers 11, 12, 13, or 101, and information may be changed into an electrical signal and may be taken out.

[0161]

Here, unless the permeability of the control light in the heat lens formation components 1, 2, and 3 is 0%, the control light of the part equivalent to permeability also penetrates and carries out outgoing radiation of the heat lens formation components 1, 2, and 3. In order to avoid that this control light carries out incidence to a latter heat lens formation component etc., and raises malfunction thru/or a cross talk, it is necessary to bring the permeability of each control light in the heat lens formation components 1, 2, and 3 to 0% close infinite. Furthermore, it is desirable to form the wavelength selection transparency filters 81, 82, and 83 the back of the heat lens formation components 1, 2, and 3 or behind condenser lenses 41, 42, and 43. As these wavelength selection transparency filters, the light of the wavelength band of each control light is intercepted completely, and on the other hand, if it is the wavelength selection transparency filter which can penetrate efficiently the light of the wavelength band of the control light for signal light and a latter optical-path change device, the thing of well-known arbitration can be used. For example, plastics and glass which were colored with coloring matter, the glass which prepared dielectric multilayers in the front face can be used. The thin film which consists of such a charge of wavelength selection transparency filter material may be formed in the front face of condenser lenses 41, 42, and 43 by technique, such as a coating method and the sputtering method, and the function as said wavelength selection transparency filter may be demonstrated.

[0162]

The optical controlling expression optical-path change mold lightwave signal transmission equipment of this example connects with a three-step serial the optical-path change device which consists of "a condenser lens, a heat lens formation component, a light-receiving lens, and a mirror with a hole." Therefore, it receives that signal light goes straight on and carries out incidence to an optical fiber 101 when all control light is switched off. When the signal light 211 switches off the control light 21 to an optical fiber 11 when the control light 21 is turned on, and the control light 22 is turned on to it, the signal light 212 to an optical fiber 12 Furthermore, when the control light 21 and 22 is switched off and the control light 23 is turned on, an optical path is changed to an optical fiber 13, and the signal light 213 carries out outgoing radiation to it. A next example explains the case which turns on two or more control light to coincidence.

[0163]
In the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 1, in order to measure the optical speed of response of the optical-path change device of the 1st step, signal light was made into continuation light, on the other hand, the control light 121 was irradiated as a square wave chopped-light line of a duty ratio 1:1 by the frequency of several Hz to 100kHz, and the size of the signal luminous-intensity amplitude by which the optical-path change was carried out was compared.
[0164]
the wave of the control light which led the control light 121 from the control light light source 21 shown in drawing 1 to the photodetector, and was measured on the oscilloscope -- the wave of the signal light which led to the photodetector the signal light 211 by which the optical-path change was carried out corresponding to blinking of 1210 and the control light 121, and was measured on the oscilloscope -- 1220 is shown in drawing 15 and drawing 16 . In addition, the axis of ordinate of drawing 16 is expanded by 3 times in the case of drawing 15 . moreover, the wave of the signal light corresponding to [set the frequency of the square wave which is intermittent in the control light 121 as 200Hz thru/or 100kHz, and] intermittence of the signal light at that time -- the result of having measured the amplitude L of 1220 is shown in drawing 17 .
[0165]
the wave of the signal light corresponding to [are 500Hz in frequency of the square wave which is intermittent in the control light 121 (drawing 1) in drawing 15 , and] intermittence of the signal light at this time -- when the amplitude L of 1220 was set to 1 of criteria, in 2kHz, the amplitude L was about 1 from the frequency range 0.2 of the square wave which is intermittent in the control light 121 (drawing 1). That is, it was checked in 500 microseconds that a perfect optical-path change is possible. This is the high-speed response of more than twice compared with the optical switch (a speed of response is ms order) using the thermooptic effect which used the electric heater.
[0166]
furthermore, the wave of signal light [in / as an example at the time of raising a frequency / the frequency of 20kHz] -- 1220 is shown in drawing 16 . If control light is switched off before the optical-path change by the thermal lensing effect is completed so that drawing 16 may show, the wave of signal light becomes the shape of a cutting edge of a saw, and the amplitude L becomes small. That is, if the speed of response of a thermal lensing effect is exceeded, the change of an optical path will become imperfect, and a part of signal light goes straight on, without carrying out an optical-path change.
[0167]
When the signal light 122 and 123 was respectively made intermittent and the same measurement as that of the optical speed of response measurement performed in the above optical-path change devices of the 1st step was carried out in the optical-path change device of the 2nd step and the 3rd step, the high-speed response equivalent to the 1st step was shown.
[0168]
In order to measure the endurance of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 1, signal light was made into continuation light, on the other hand, the control light 121,122 and 123 was respectively irradiated as a square wave chopped-light line of a duty ratio 1:1 by 1kHz of frequency numbers, and the time amount of the signal luminous-intensity amplitude by which the optical-path change was carried out was compared. Consequently, even if 10,000 hours passed continuously respectively, the signal luminous-intensity amplitude was not decreased.
[0169]
Although the experiment to which the polarizing element of one sheet is inserted in signal light and control light, and various polarization angles are changed was conducted in order to verify the polarization dependency of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 1, the polarization dependency was not accepted at all.
[0170]
In order to investigate the cross talk property of the outgoing radiation rectilinear-propagation light of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 1, and optical-path change light, Putting out lights, and lighting and lighting of only the control light light source 22 of only the control light light source 21 all control light -- And the place which measured the outgoing radiation light reinforcement from optical fibers 101, 11, 12, and 13 about each case of lighting of only the control light light source 23, The leakage-at-bulb light (cross talk) reinforcement to the target outgoing radiation light reinforcement was as feeble as 2000 thru/or 8000:1 (-33 thru/or 39dB).

[0171]
[Example 2]
Drawing 20 showing an example of the optical intensity distribution in a signal light beam cross section is the optical intensity distribution of the signal light beam cross section when corresponding in optical arrangement as shown in drawing 8 (b) and drawing 10 (b), setting it as the location 6 (outgoing radiation side of light) near the light-receiving lens 41 of the heat lens formation component 1 which shows a focus (condensing point) to drawing 7 (b), and irradiating control light. In this case, the optical reinforcement for a core is stronger than the optical reinforcement for a core when not irradiating control light (drawing 18). In this case, the optical reinforcement of the core of a signal light beam cross section reaches also several times at the time of a control **** exposure, although it is dependent on the physical relationship of control light reinforcement and the heat lens formation component 1, and a focus 6.
[0172]
Therefore, if the mirror 61 with a hole is installed in this case, most signal light beams will pass through the hole 161 of a mirror with a hole. Here, if magnitude of the hole 161 of the mirror 61 (62 and 63) with a hole is optimized (diameter of 2mm when it is this example 2), signal light reflected by the mirror 61 with a hole can be made into zero as a matter of fact. However, even if it optimizes the magnitude of the hole 161 of the mirror 61 with a hole, when not irradiating control light (drawing 9 (a), drawing 8), it cannot be prevented the amount of [of signal light as shown in drawing 10 (a)] core's passing through a hole 161 as a leakage signal light 118. That is, in the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 2, when the optical intensity distribution of a signal light beam cross section are close to Gaussian distribution thru/or Gaussian distribution, a certain amount of leakage signal light 118 (cross talk) surely occurs to the signal light 211 in drawing 10 (a).
[0173]
However, such a leakage signal light can be made into zero as a matter of fact by changing the optical intensity distribution of the signal light beam cross section which carries out incidence to a heat lens formation component. That is, as shown in drawing 1 and drawing 2 b, after operating orthopedically the signal light 110 which carried out outgoing radiation using a collimate lens 30 from an optical fiber 100, it can perform easily making the optical intensity distribution of a signal light beam cross section distribution of the shape of a ring which is equivalent to drawing 19 by the beam cross-section ring-ized lens group 321 which consists of a cone prism mold lens etc. If it returns to a parallel ray with the light-receiving lens 41 after converging the signal light 110 of such cross-section light intensity distribution so that it may pass through the focal location 6 (drawing 10 (a)) with a condenser lens 31, and making the heat lens formation component 1 penetrate The optical intensity distribution of the light beam cross section are strong in a circumference part so that it may be equivalent to drawing 19 , and since the amount of core becomes "the shape of a ring of zero" as a matter of fact, when the mirror 61 with a hole is installed, they can lose the leakage at bulb of the signal light which passes through the hole 161 as a matter of fact. Even if the optical intensity distribution of a signal light beam cross section are rings "-like" in this way, when it irradiates control light like drawing 9 (b) and the heat lens 60 is made to form transitionally, the optical intensity distribution of a signal light beam cross section pass through the hole 161 of the mirror 61 with a hole as a convergence rectilinear-propagation signal light 119 of the shape of a sharp beam.
[0174]
By adjusting in optical arrangement which is illustrated to drawing 10 , so that the focus of control light and signal light may become the location 6 near the outgoing radiation side of a heat lens formation component, and making the optical intensity distribution of a signal light beam cross section into the shape of a ring further signal light can be made to go straight on at the time of changing an optical path from the travelling direction since signal Mitsumoto 90 degrees, and carrying out outgoing radiation of the signal light, and a control light exposure at the time of a control **** exposure
[0175]
The optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 2 The optical-path change devices 91, 92, and 93 in an example 1 (drawing 1) are altogether transposed to the optical-path change device 191 which is illustrated by drawing 2 b. The focus (condensing point) of signal light and control light is set as the location 6 (outgoing radiation side of light) near the light-receiving lens 41 of the heat lens formation component 1, and are smaller than the case of an example 1 and let the hole 161 of the mirror 61 with a hole be the diameter of 2mm. In this case, in order to set the focus (condensing point) of signal light and control light as the location 6 (outgoing radiation side of light) near the light-receiving lens 41 of the heat lens formation component 1, as for the permeability of the control

light in the light absorption layer membrane of a heat lens formation component, it is desirable that they are 1 thru/or 5%. When the beam cross-section light intensity distribution of the signal light 110 which carries out incidence to the optical-path change device 191 are similar to Gaussian distribution thru/or Gaussian distribution and are not rings-like, it is desirable to make the optical intensity distribution of a signal light beam cross section into the shape of a ring by the beam cross-section ring-ized lens group 321 which consists of a cone prism mold lens etc. Moreover, since the convergence rectilinear-propagation signal light 119 which carries out outgoing radiation of the heat lens 60 formed of the light absorption of control light has the small beam diameter when signal light and control light are irradiated by coincidence, when condensing in the latter part, a beam waist will become larger as mentioned above. In order to avoid this, it is desirable to carry out outgoing radiation of the convergence rectilinear-propagation signal light 119 with the beam expander 331 as a signal light 111 made to expand to the radius of 5mm equivalent to the incidence signal light 110.

[0176]

The combination of lighting of the control light 121,122,123 of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 2 and the relation of an optical-path change are as follows. When the control light 121 is switched off at least, it is reflected by the reflector of the mirror 61 with a hole, and outgoing radiation of the signal light 110 is carried out as an optical-path change signal light 211, it is condensed with a condenser lens 71 and incidence of it is carried out to an optical fiber 11. When the control light 121 is turned on, after the signal light 110 passes through the hole 161 of the mirror 61 with a hole as a convergence rectilinear-propagation signal light 119, with the beam expander 331, it is expanded to the same beam diameter as the incidence signal light 110, and carries out incidence to the optical-path change device 192 (drawing 4) of the 2nd step. When the control light 121 lights up and the control light 122 is switched off, outgoing radiation of the signal light 111 is carried out as an optical-path change light 212, and it carries out incidence to an optical fiber 12. When signal light goes straight on when the control light 121 and 122 is on to coincidence, incidence is carried out to the optical-path change device 193 (drawing 4) of the 3rd step as a signal light 112, and the control light 121 and 122 lights up to coincidence and the control light 123 has gone out, incidence is carried out to an optical fiber 13 as an optical-path change light 213. When the control light 121,122,123 is altogether on, finally outgoing radiation of the signal light 110 is carried out as a rectilinear-propagation signal light 113, it is condensed with a condenser lens 401 and incidence of it is carried out to an optical fiber 101.

[0177]

In order to measure the optical speed of response of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 2, signal light was made into continuation light, on the other hand, the control light 121 was irradiated as a square wave chopped-light line of a duty ratio 1:1 by the frequency of several Hz to 100kHz, and the size of the signal luminous-intensity amplitude by which the optical-path change was carried out was compared. Consequently, when the amplitude on the strength did not change to 2kHz but a frequency was further raised on the basis of the signal luminous-intensity amplitude at the time of 1Hz, the amplitude on the strength was decreased gradually and reduced by half at the time of 10kHz. That is, it was checked in 500 microseconds that a perfect optical-path change is possible. This is the high-speed response of more than twice compared with the optical switch using the thermooptic effect which used the electric heater. Even if similarly intermittent in the control light 122 and 123, the speed of response equivalent to the case where it is intermittent in 121 was observed.

[0178]

In order to measure the endurance of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 2, signal light was made into continuation light, on the other hand, the control light 121,122,123 was respectively irradiated as a square wave chopped-light line of a duty ratio 1:1 on the frequency of 1kHz, and the time amount of the signal luminous-intensity amplitude by which the optical-path change was carried out was compared. Consequently, even if 10,000 hours passed continuously respectively, the signal luminous-intensity amplitude was not decreased.

[0179]

In order to investigate the cross talk property of the outgoing radiation rectilinear-propagation light of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 2, and optical-path change light, Putting out lights, and lighting and lighting of only the control light 121 and 122 of only the control light 121 all control light -- and the control light 121,122,123 -- about each case of lighting altogether When the outgoing radiation light reinforcement from optical fibers 101, 11, 12, and 13 was measured, the leakage-at-bulb light (cross talk) reinforcement to the outgoing radiation light

reinforcement made into the purpose was as feeble as 1000 thru/or 2000:1 (-30 thru/or 33dB).
[0180]
[Example 3]
The include angle of the optical-path change to the optical axis of the signal light 110 can be changed about freely in 5 times to 175 degrees by changing the installation include angle (it being 45 degrees to the optical axis of the signal light 110) of the mirror 61 with a hole in an example 1, and calculating and determining the configuration (the die length of the major axis to a minor axis) of the ellipse-like hole 161 using a trigonometric function based on an installation include angle. The installation include angle of the mirrors 62 and 63 with a hole after the 2nd step can be changed similarly.
[0181]
Moreover, the installation location of the mirror 61 with a hole can be rotated by the ability setting a revolving shaft as the optical axis of the signal light 110, and the direction of the optical-path change to the optical axis of the signal light 110 can be freely changed in 0 to 360 degrees also by moving the location of condenser lens 71 grade. The installation location of the mirrors 62 and 63 with a hole after the 2nd step can also be changed similarly.
[0182]
[Example 4]
The outline configuration of the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 4 is shown in drawing 5 . In drawing 5 , the signal light light source 20, the control light light sources 21, 22, and 23, dichroic mirrors 51, 52, and 53, the condenser lens 10, the optical fiber 100, and the collimate lens 30 are the same as that of the case of an example 1.
[0183]
The optical controlling expression optical-path change mold lightwave signal transmission equipment of drawing 5 Three optical-path change devices are further added and connected with one optical-path change device 92 of the 2nd step of an example 1 with a space joint mold in the latter part of the optical-path change device 91 of the 1st step. According to a total of seven optical-path change devices Moreover, the optical-path change of the outgoing radiation point of the signal light 120 is carried out with the combination of coincidence lighting of three kinds of control light in the eight directions of optical fibers 101, 102, 103, 104, 13, 14, 15, and 16. That is, generally it becomes possible theoretically by connecting one optical-path change device in which 2 lengthens [the optical-path change of the direction of n-th power of 2] n the n-th power with the combination of the lighting situation of n kinds of control light as two or more integers. A practical combination number of stages is decided by combination of the permeability of the signal light per one step of optical-path change device in fact. When the attenuation factor of the "change signal light" to which the optical path was changed 85% (it considers as signal strength and 0.7dB is decreased) in the permeability of the "rectilinear-propagation signal light" from which an optical path does not change by the optical-path change device is assumed to be 80% (this 1.0dB attenuation), comprehensive permeability when all three steps of comprehensive permeability at the time of going straight on altogether be changed 61.4% (this 2.1dB attenuation) is 51.2% (this 2.9dB attenuation). The combination of coincidence lighting of three kinds of control light 121,122,123 and the signal light outgoing radiation point are collectively shown in Table 2.
[0184]
[Table 2]

	制御光			信号光出射先
	121	122	123	
制御光の組合せ	off	off	off	101
	off	off	on	13
	off	on	off	14
	off	on	on	102
	on	on	off	104
	on	on	on	16
	on	off	off	15
	on	off	on	103

[0185]
The coloring matter solution restoration type heat lens formation component filled up with the solution of the coloring matter [1] which absorbs the signal light 121 with a wavelength of 532nm like the case of an example 1 as a heat lens formation component of the optical-path change device 91 of the 1st step was used. It was presupposed that a wavelength permeability property is also the same as that of the case of an example 1.
[0186]
The coloring matter solution restoration type heat lens formation component filled up with the solution of the coloring matter [2] with which the signal light 122 with a wavelength of 670nm is absorbed like the case of an example 1 as a heat lens formation component of the optical-path change devices 92 (it combines with the rectilinear-propagation light 111 from the optical-path change device 91 spatially) and 95 (it combines with the change light 211 from the optical-path change device 91 spatially) of the 2nd step in any case was used. A wavelength permeability property is explained later.
[0187]
The optical-path change device 93 (it combines with the rectilinear-propagation light 112 from the optical-path change device 92 spatially) of the 3rd step, 94 (said -- the change light 212 from 92 -- spatial -- association), and 96 (said -- the change light 215 from 95 -- spatial -- association) -- The coloring matter solution restoration type heat lens formation component filled up with the solution of the coloring matter [3] with which the signal light 123 with a wavelength of 800nm is absorbed like the case of an example 1 as a heat lens formation component of 97 (it combines with the rectilinear-propagation light 115 from the optical-path change device 95 spatially) in any case was used. A wavelength permeability property is explained later.
[0188]
In the optical-path change devices 92, 93, and 97 of the latter part combined with the rectilinear-propagation light from the optical-path change device of the preceding paragraph here The location which is equivalent to the location 5 of drawing 7 (a) and drawing 9 in signal light and control light like the case of the optical-path change device in an example 1 with a condenser lens 31 etc., That is, it adjusted so that a focus might be connected in the location near the plane of incidence of the light absorption layer membrane of a heat lens element, and magnitude of the holes 161, such as the mirror 61 with a hole, etc. was also further made the same as that of the case of an example 1. It is efficient and doing in this way enables the rectilinear-propagation light from the optical-path change device of the preceding paragraph to go straight on or change by the latter optical-path change device. In the optical-path change devices 92, 93, and 97, 0.0 thru/or 0.2%, the permeability of each control light adjusted so that the permeability of signal light 850mn might become 85 thru/or 99%.
[0189]
In the optical-path change devices 94, 95, and 96 of the latter part combined with the optical-path change light (light of a ring-like cross section) from the optical-path change device of the preceding paragraph on the other hand The location which is equivalent to the location 6 of drawing 7 (b) and drawing 10 in signal light and control light like the case of the optical-path change device 191 in an example 2 with a condenser lens 31 etc., That is, it adjusted so that a focus might be connected in the location near the outgoing radiation side of the light absorption layer membrane of a heat lens element, and magnitude of the holes 161, such as the mirror 61 with a hole, etc. was also further made the same as that of the case of an example 2. However, in order that space association might be carried out respectively and the signal light 212,211,215 of the shape of a ring to which the optical path was changed might carry out incidence to the optical-path change devices 94, 95, and 96 from the optical-path change device of the preceding paragraph with the shape of a ring, the beam cross-section ring-ized lens group 321 (drawing 2 b) in the optical-path change device 191 did not prepare. On the other hand, the beam expander 331 (drawing 2 b) for expanding the beam diameter of the convergence rectilinear-propagation signal light 119 was formed in each of the optical-path change devices 94, 95, and 96.
[0190]
It is efficient and doing in this way enables the optical-path change light of the ring-like cross section from the optical-path change device of the preceding paragraph to go straight on or change by the latter optical-path change device. In the optical-path change devices 94, 95, and 96, 1.0 thru/or 5.0%, the permeability of each control light adjusted so that the permeability of 850nm of signal light might become 85 thru/or 99%.
[0191]

About the rectilinear-propagation light 113,114,116,117 which carries out outgoing radiation from the optical-path change device of the 3rd step (the last stage), respectively, it is condensed with a condenser lens 401,402,403,404 and incidence is carried out to the outgoing radiation signal light optical fiber 101,102,103,104. About the optical-path change light 213,214,216,217 which similarly carries out outgoing radiation, respectively, it is condensed with condenser lenses 73, 74, 75, and 76, and incidence is carried out to the outgoing radiation signal light optical fibers 13, 14, 15, and 16. The specification of these optical fibers is the same as that of the case of an example 1.

[0192]

In the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 4, when the optical speed of response of the 1st thru/or the 3rd step of optical-path change device was measured like the case of an example 1, the same result was obtained.

[0193]

When the endurance of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 4 was measured like the case of an example 1, even if each optical-path change device passed continuously respectively for 10,000 hours, the signal luminous-intensity amplitude was not able to be decreased but was able to check high endurance.

[0194]

Although the experiment to which the polarizing element of one sheet is inserted in signal light and control light, and various polarization angles are changed was conducted in order to verify the polarization dependency of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 4, the polarization dependency was not accepted at all.

[0195]

In order to investigate the cross talk property between eight outgoing radiation signal light of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 4, The place which measured the outgoing radiation light reinforcement from optical fibers 13, 14, 15, and 16,101,102,103,104 about each case of eight kinds of combination of the control light-spot LGT shown in Table 2, The leakage-at-bulb light (cross talk) reinforcement to the target outgoing radiation light reinforcement was as feeble as 1000 thru/or 8000:1 (-30 thru/or 39dB).

[0196]

[Example 5]

The outline configuration of the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 5 is shown in drawing 6 . This example 5 transposes the space joint mold optical-path change devices 91, 92, 93, 94, 95, 96, and 97 (it is equivalent to drawing 2 a or drawing 2 b) in the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 4 to the optical-fiber joint mold optical-path change devices 910, 920, 930, and 940,950,960,970 (altogether equivalent to drawing 3). In all said optical-fiber joint mold optical-path change devices, it adjusted so that a focus might be connected like the case of the optical-path change device in an example 1 in the location which is equivalent to the location 5 of drawing 7 (a) and drawing 9 in signal light and control light, i.e., the location near the plane of incidence of the light absorption layer membrane of a heat lens element, with a condenser lens 31 etc., and magnitude of the holes 161, such as the mirror 61 with a hole, etc. was also further made the same as that of the case of an example 1. Moreover, in said all optical-fiber joint mold optical-path change devices, the configuration, ingredient, and permeability property of a heat lens formation component presupposed that it is the same as that of the case of an example 1. The die length of the optical fiber which connects each optical-fiber joint mold optical-path change device was set to 10 thru/or 100m supposing the application in general domestic, a hospital, and office etc.

[0197]

In order to compensate the loss of the control light based on optical-fiber association, in the optical-path change device of a whole page, it adjusted by heightening the output of the control light light sources 21, 22, and 23 so that the power of the control light which carries out incidence to a heat lens formation component might be set to 2 thru/or 5mW. Moreover, the output of the signal light light source was also adjusted so that eight outgoing radiation signal light might become sufficient power respectively.

[0198]

Incidence of the signal light by which was made to carry out incidence of the rectilinear-propagation outgoing radiation signal light of the optical-path change devices 930, 940, 960, and 970 of the 3rd step to electric eyes 1013, 1014, 1016, and 1017 respectively via an optical fiber and a collimate lens, and the optical-path change was carried out was respectively carried out to electric eyes 2013, 2014, 2016, and 2017

via the optical fiber and the collimate lens.
[0199]
The combination of coincidence lighting of three kinds of control light 121,122,123 and the correspondence relation of a signal light outgoing radiation point electric eye to this example 5 are collectively shown in Table 3.
[0200]
[Table 3]

	制御光			信号光出射先
	121	122	123	
制御光の組合せ	off	off	off	1013
	off	off	on	2013
	off	on	off	1014
	off	on	on	2014
	on	on	off	1016
	on	on	on	2016
	on	off	off	1017
	on	off	on	2017

[0201]
It measured like [cross talk / the optical speed of response of the optical controlling expression optical-path change mold lightwave signal transmission equipment of this example 5, endurance, a polarization dependency, and] the case of an example 4, and the result more than an EQC thru/or an EQC was obtained.
[Availability on industry]
[0202]
Optical controlling expression optical-path change mold lightwave signal transmission equipment and the lightwave signal optical-path change approach are suitably used at the office of a company, works, a hospital, ordinary homes, etc. in the system which distributes mass digital information, such as highly minute image data and a highly minute video data, to a high speed to one specific place of a server to two or more clients.
[Brief Description of the Drawings]
[0203]
[Drawing 1 a] It is the outline block diagram of the optical controlling expression optical-path change mold lightwave signal transmission equipment written without omitting the optical-path change device of an example 1.
[Drawing 1 b] It is the outline block diagram of the optical controlling expression optical-path change mold lightwave signal transmission equipment which symbolized and carried out the simple notation of the optical-path change device of an example 1.
[Drawing 2 a] It is drawing having shown symbolizing and carrying out the simple notation of the outline block diagram of the optical-path change device of a space joint mold.
[Drawing 2 b] It is drawing having shown symbolizing and carrying out the simple notation of the outline block diagram of the optical-path change device of a space joint mold.
[Drawing 3] It is drawing having shown symbolizing and carrying out the simple notation of the outline block diagram of the optical-path change device of an optical-fiber joint mold.
[Drawing 4] It is drawing which symbolized and indicated the outline block diagram of the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 2 by simple.
[Drawing 5] It is drawing which symbolized and indicated the outline block diagram of the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 4 by simple.
[Drawing 6] It is drawing which symbolized and indicated the outline block diagram of the optical controlling expression optical-path change mold lightwave signal transmission equipment of an example 5 by simple.

[Drawing 7] It is drawing having shown how depending on which light in case a heat lens is not formed progresses.
[Drawing 8] When the location of a beam waist is adjusted to (b) a (a) or outgoing radiation close-attendants side the beam incidence close-attendants side of a light absorption layer membrane, it is drawing having shown how depending on which light when a heat lens is formed progresses.
[Drawing 9] It is the mimetic diagram having shown the principle of the optical-path change at the time of adjusting the location of a beam waist to the beam incidence close-attendants side of a light absorption layer membrane.
[Drawing 10] It is the mimetic diagram having shown the principle of the optical-path change at the time of adjusting the location of a beam waist to the beam outgoing radiation close-attendants side of a light absorption layer membrane.
[Drawing 11] It is the sectional view which illustrated the example of a configuration of a heat lens formation component.
[Drawing 12] It is the sectional view which illustrated the example of a configuration of a heat lens formation component.
[Drawing 13] It is drawing showing the relation of the slit and light beam which were used for optical intensity-distribution measurement of a signal light beam cross section.
[Drawing 14] It is a mimetic diagram showing a situation [/ near the focus of the Gaussian beam which it converged with the condenser lens etc.].
[Drawing 15] It is drawing showing the wave of the control light observed with the oscilloscope, and signal light.
[Drawing 16] It is drawing showing the wave of the control light observed with the oscilloscope, and signal light.
[Drawing 17] It is drawing showing the relation of signal luminous intensity (amplitude) by which the optical-path change was carried out with the frequency which is intermittent in control light.
[Drawing 18] It is drawing showing the optical intensity distribution of the beam cross section of signal light.
[Drawing 19] It is drawing showing the optical intensity distribution of the beam cross section of signal light.
[Drawing 20] It is drawing showing the optical intensity distribution of the beam cross section of signal light.
[Drawing 21] It is the mimetic diagram which illustrated the coloring matter solution restoration type heat lens formation component.
[Drawing 22] It is drawing which expressed respectively the permeability spectrum of the solution of coloring matter [1], [2], and [3] with a continuous line, the chain line, and an alternate long and short dash line.
[Description of Notations]
[0204]
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[Translation done.]

* NOTICES *

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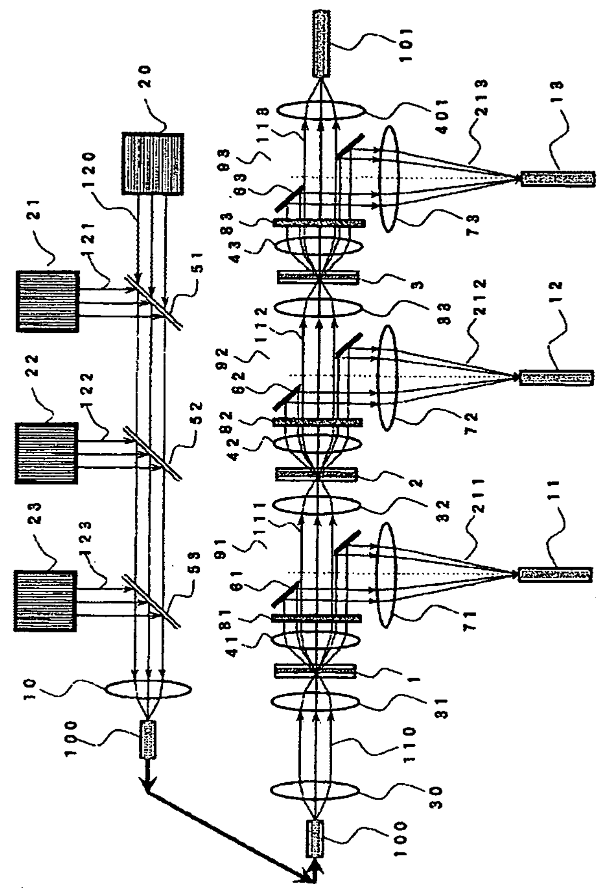
DRAWINGS

[Drawing 1 a]



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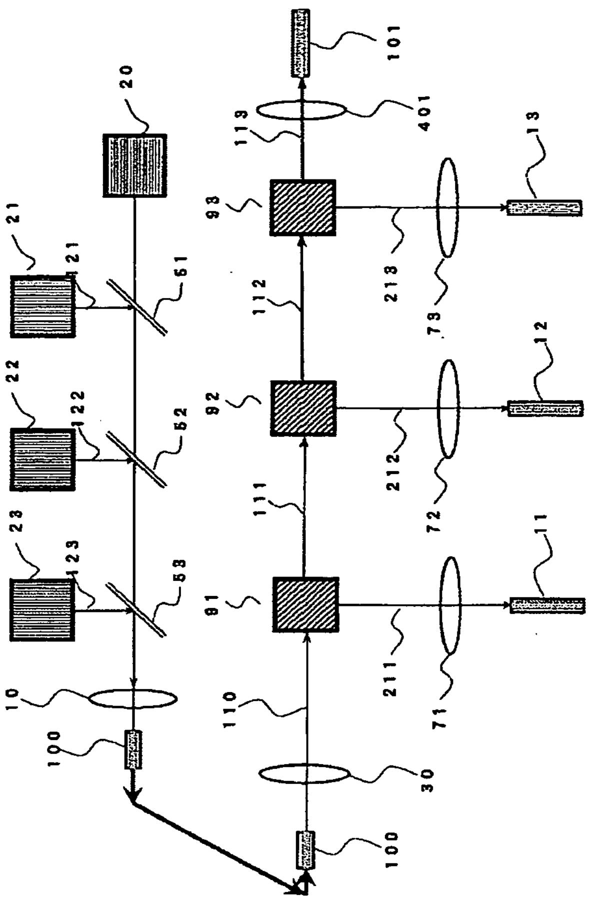

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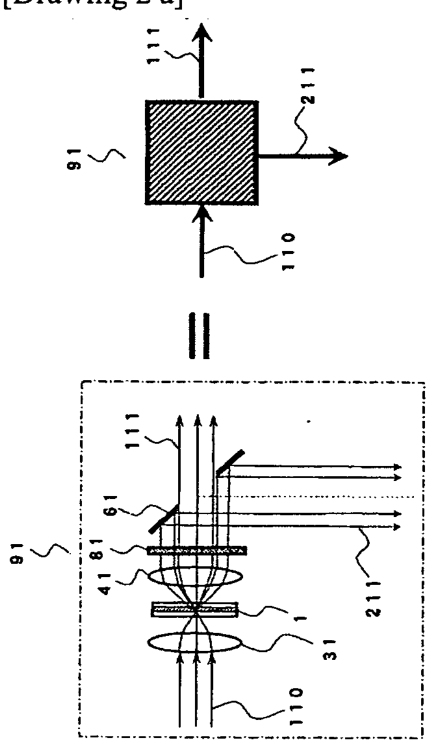

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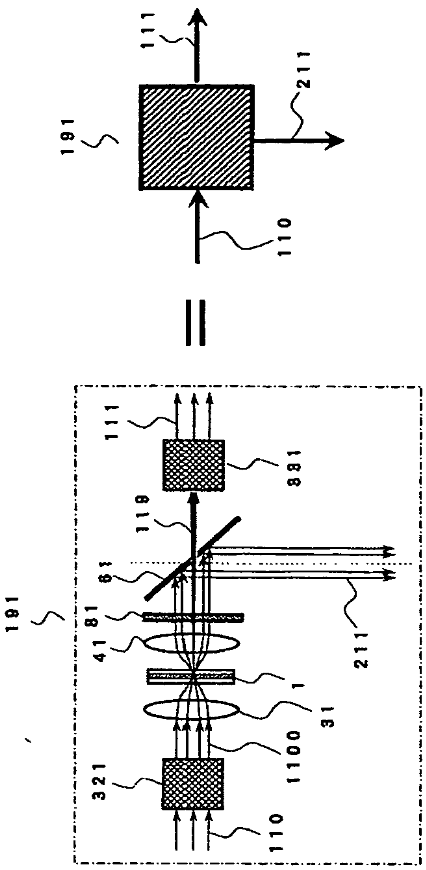

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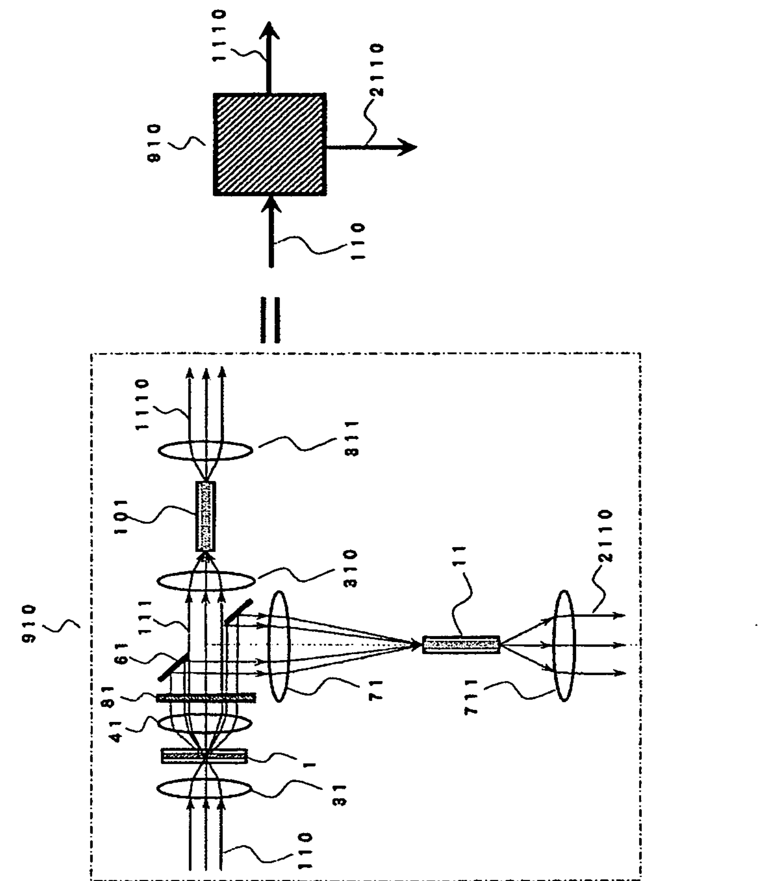
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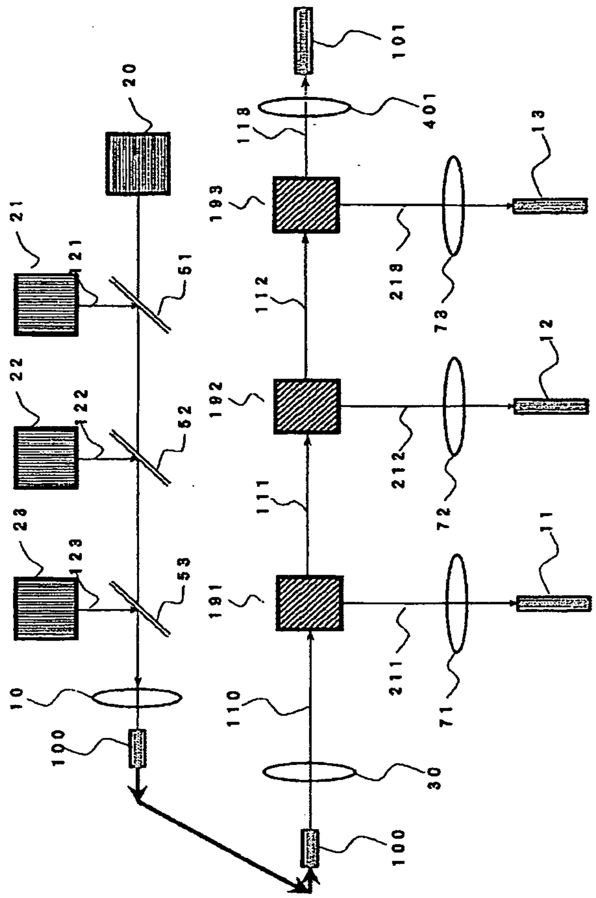

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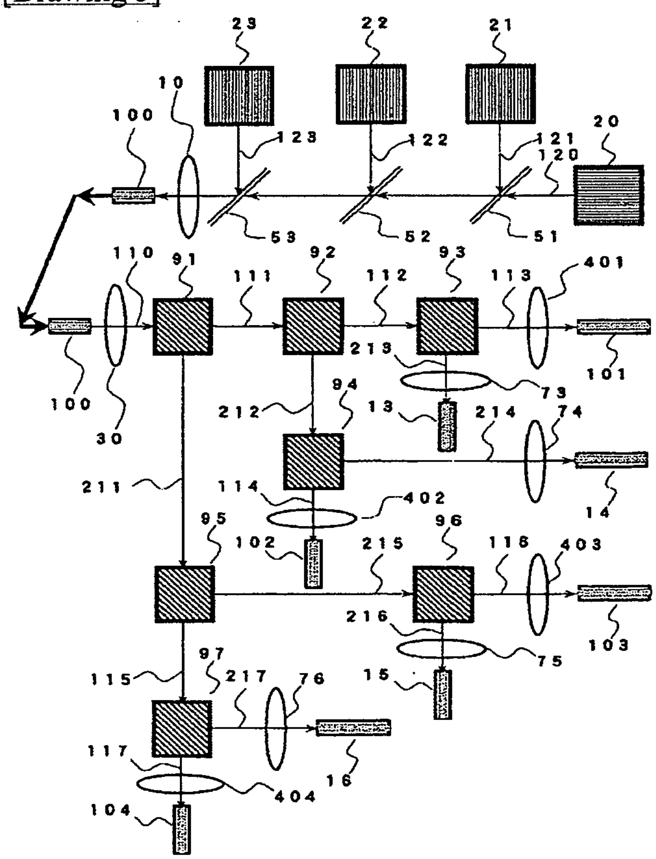

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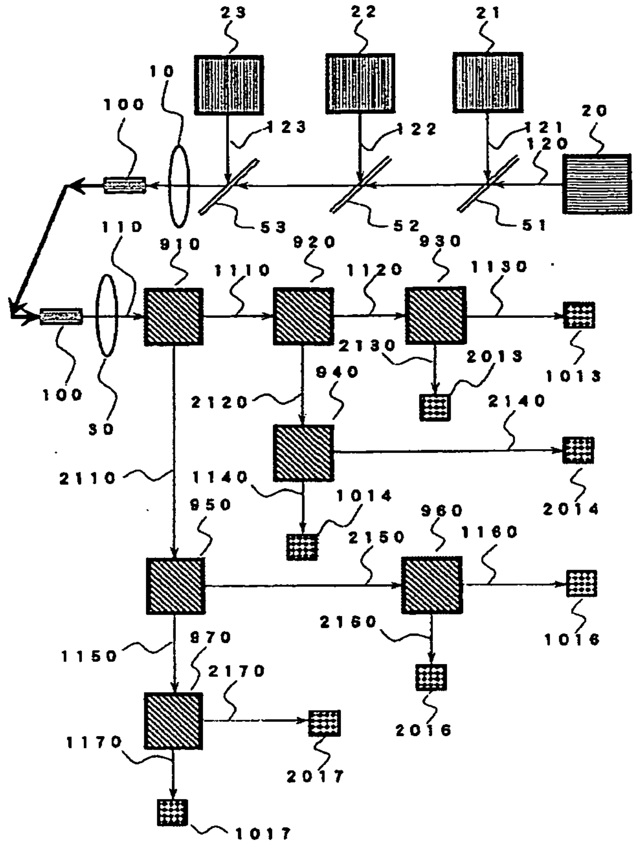

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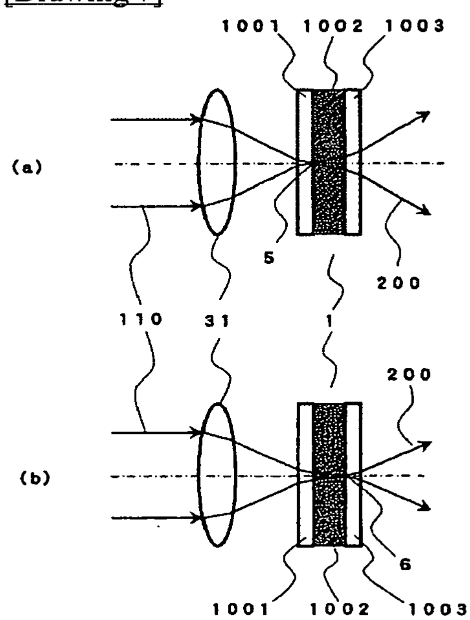

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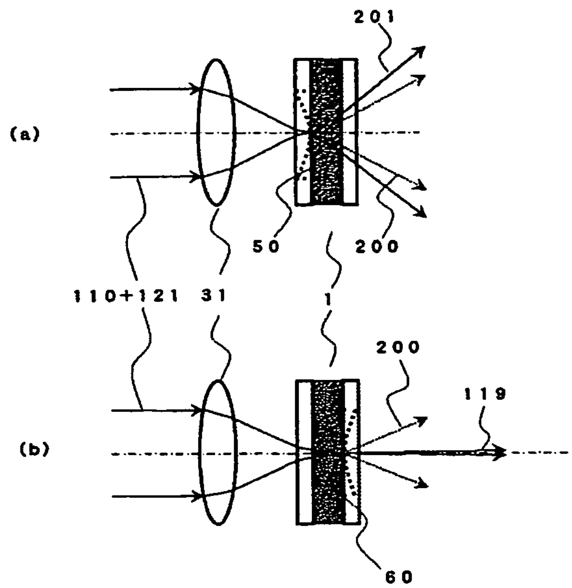

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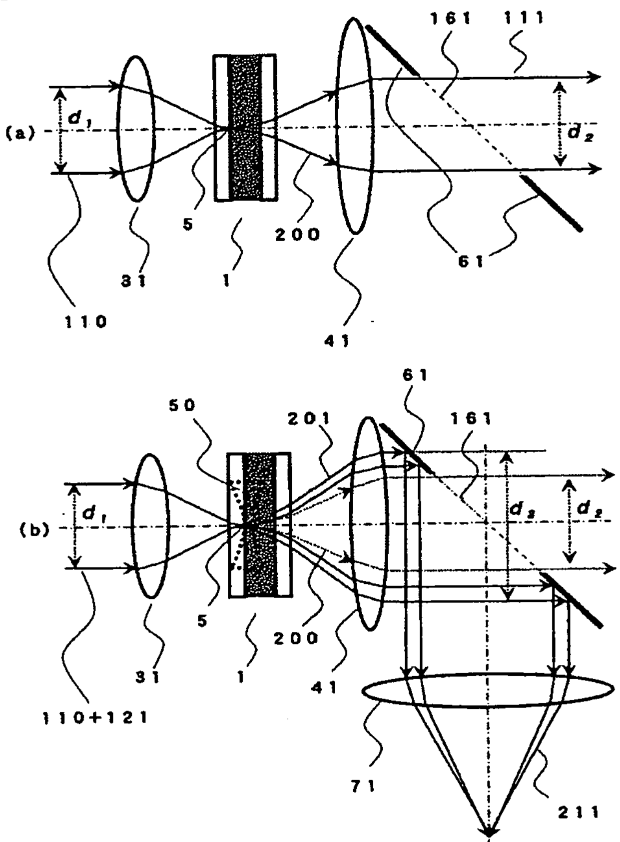

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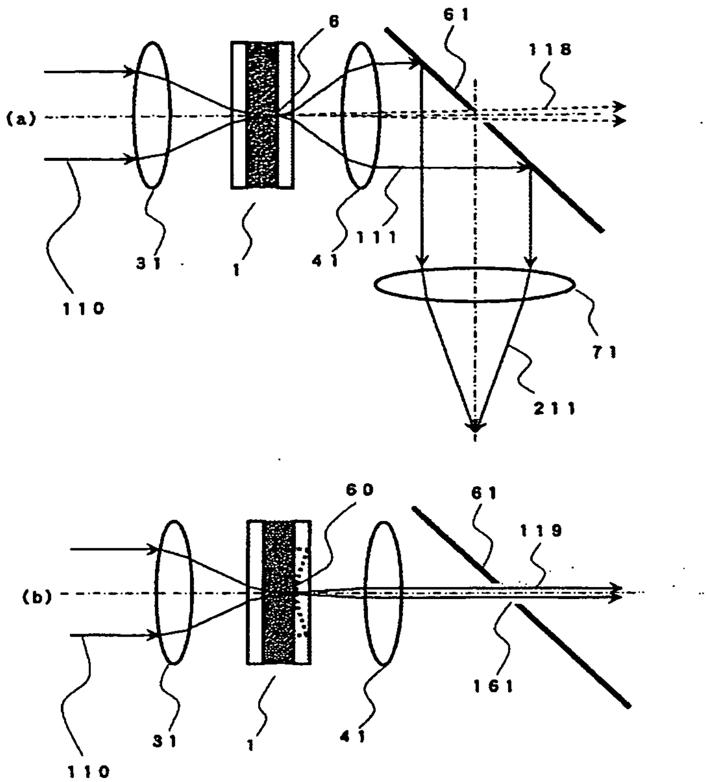

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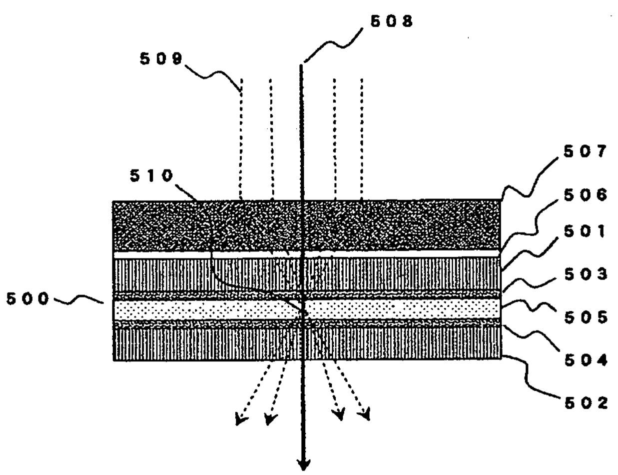

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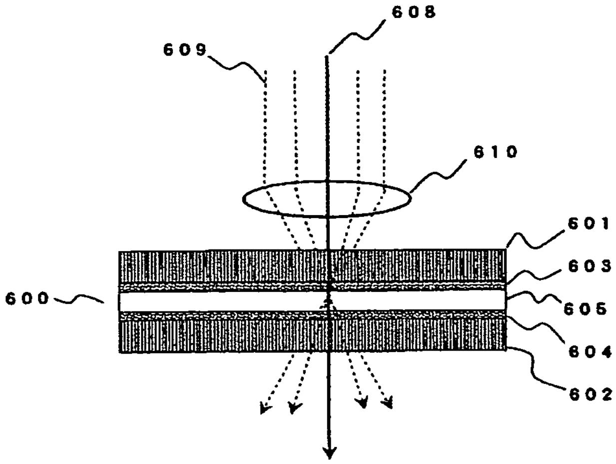

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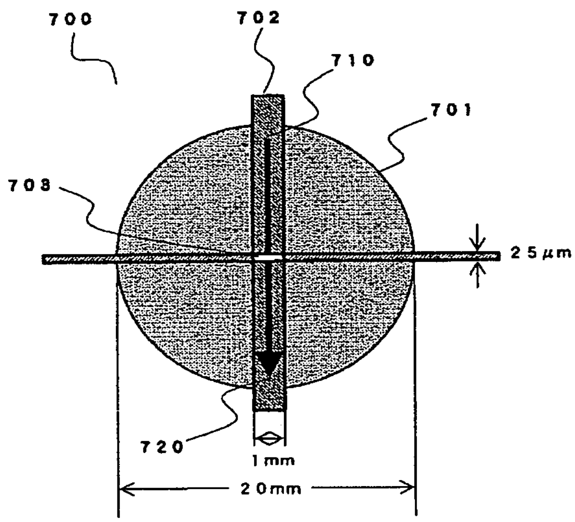

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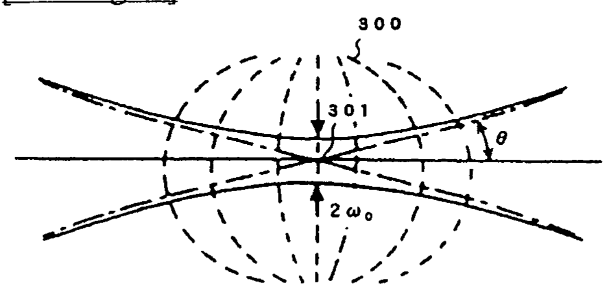

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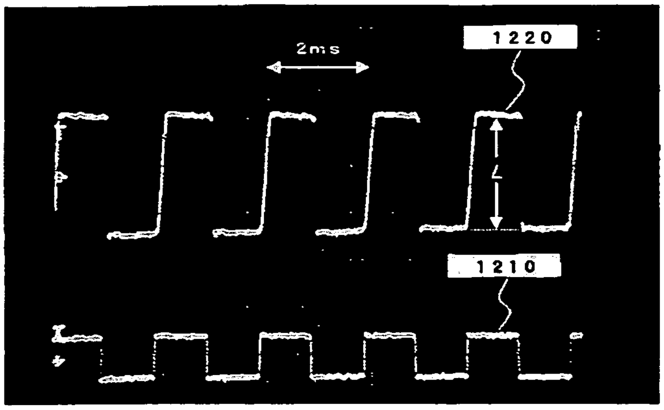

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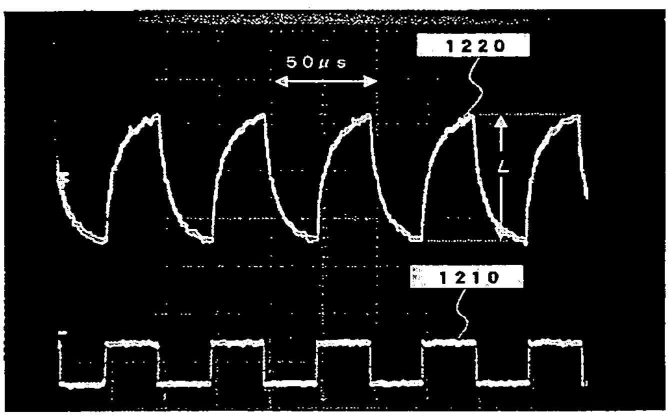

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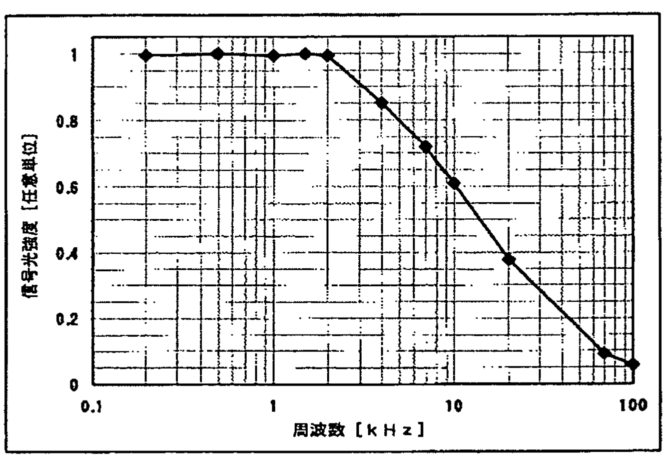

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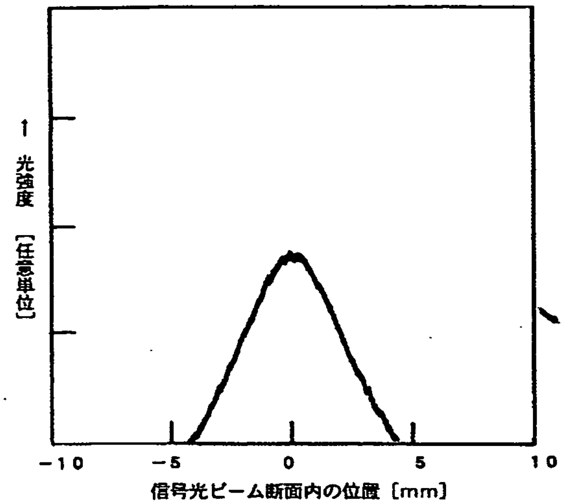

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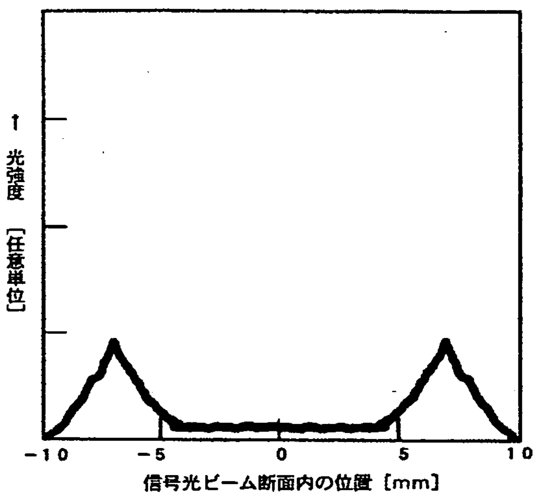

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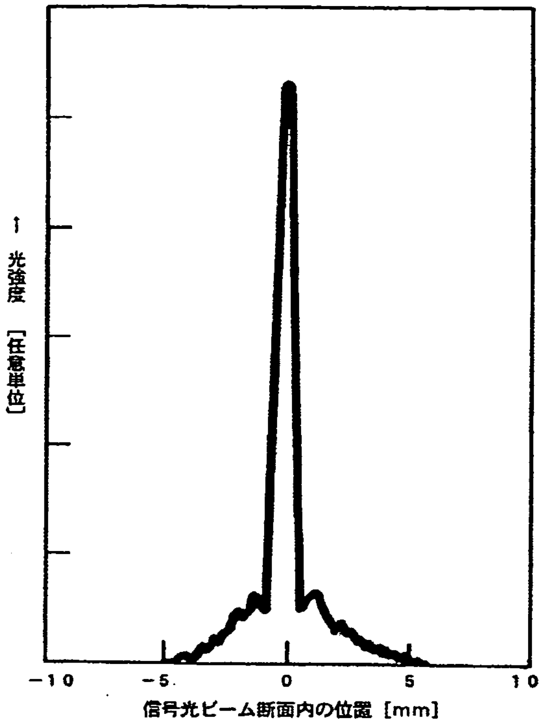

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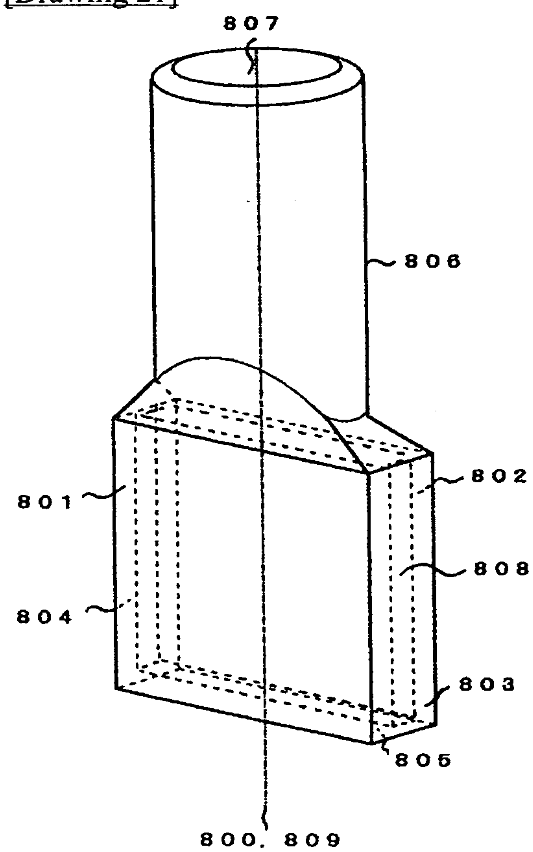

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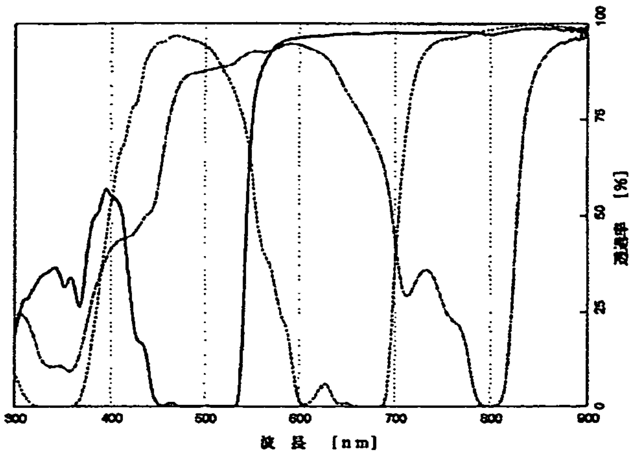

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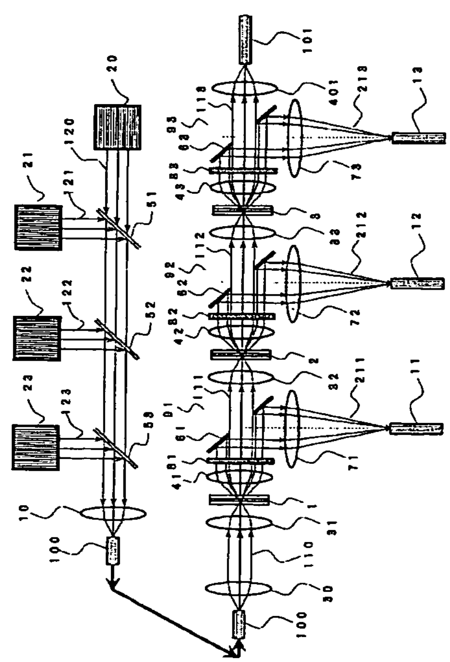
最終頁に続く

(54)【発明の名称】光制御式光路切替型光信号伝送装置および光信号光路切替方法

(57)【要約】　　（修正有）
【課題】高速で作動し、耐久性の高い、偏波依存性のない、光制御式光路切替型光信号伝送装置および光信号光路切替方法を提供する。
【解決手段】少なくとも光吸収層膜を含む熱レンズ形成素子１，２，３中の光吸収層膜に、前記光吸収層膜が吸収する波長帯域から選ばれる互いに異なる波長の制御光１２１，１２２，１２３、および、前記光吸収層膜が吸収しない波長帯域から選ばれる単一波長の信号光１１０，１１１，１１２を各々収束させて照射し、少なくとも前記制御光１２１，１２２，１２３が前記光吸収層膜内において焦点を結ぶように配置を調整し、前記光吸収層膜が前記制御光１２１，１２２，１２３を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって光路を変更させる光信号光路切替方法である。
【選択図】図１ａ



【特許請求の範囲】
【請求項１】
１種類以上の波長の信号光を照射する信号光光源と、
前記信号光とは異なる２種類以上の波長の制御光を照射する制御光光源と、
前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、
前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、
前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光の照射の有無に応じ、前記収束された信号光を収束させたまま出射する、または、信号光の開き角度を可変させて出射する２つ以上の熱レンズ形成素子と、
前記各熱レンズ形成素子の各々後方に設けられた、穴と反射手段とを有する鏡であって、前記特定の１種類の波長の制御光の照射の有無に応じて、前記熱レンズ形成素子を出射した信号光を前記穴に通過させ、または、前記反射手段により反射させることによって光路を変化させる鏡と、
を備えることを特徴とする光制御式光路切替型光信号伝送装置。
【請求項２】
１種類以上の波長の信号光を照射する信号光光源と、
前記信号光とは異なる２種類以上の波長の制御光を照射する制御光光源と、
前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、
前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、
熱レンズ形成素子と穴を有する鏡の組み合わせからなる２組以上の光路切替機構と、を備え、
前記熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、
前記穴を有する鏡は、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、通過させる穴と、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合に、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、または、前記受光レンズによって前記開き角度を変更させた信号光のいずれかを、反射する反射手段と、を有し光路を変更させる鏡である光制御式光路切替型光信号伝送装置。
【請求項３】
１種類以上の波長の信号光を照射する信号光光源と、
前記信号光とは異なる２種類以上の波長の制御光を照射する制御光光源と、
前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、
前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、

熱レンズ形成素子と穴を有する鏡の組み合わせからなる２組以上の光路切替機構と、を備え、

前記熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は前記収束された信号光が収束されたまま出射され、制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、

前記穴を有する鏡は、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合に、収束されたまま前記熱レンズ形成素子から出射する前記収束された信号光を通過させる穴と、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、前記開き角度を変更させるために設けられた受光レンズを透過させた信号光のいずれかを反射させる反射手段と、を有し光路を変更させる鏡である光制御式光路切替型光信号伝送装置。

【請求項４】

１種類以上の波長の信号光を照射する信号光光源と、

前記信号光とは異なる２種類以上の波長の制御光を制御する制御光光源と、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、

前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、

第１の熱レンズ形成素子と第１の穴を有する鏡との組み合わせからなる１組以上の第１の光路切替機構と、

第２の熱レンズ形成素子と第２の穴を有する鏡との組み合わせからなる１組以上の第２の光路切替機構と、を備え、

第１の熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、

第１の穴を有する鏡は、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、通過させる穴と、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合に、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、または、前記受光レンズによって前記開き角度を変更させた信号光のいずれかを、反射する反射手段と、を有し光路を変更させる鏡であり、

第２の熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は前記収束された信号光が収束されたまま出射され、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の

制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、
第２の穴を有する鏡は、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合に、収束されたまま前記熱レンズ形成素子から出射する前記収束された信号光を通過させる穴と、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、前記開き角度を変更させるために設けられた受光レンズを透過させた信号光のいずれかを反射させる反射手段と、を有し光路を変更させる鏡である光制御式光路切替型光信号伝送装置。
【請求項５】
２組以上の前記光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、直列に連結されていることを特徴とする請求項２に記載の光制御式光路切替型光信号伝送装置。
【請求項６】
２組以上の前記光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、直列に連結されていることを特徴とする請求項３に記載の光制御式光路切替型光信号伝送装置。
【請求項７】
２組以上の前記光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、直列に連結されていることを特徴とする請求項４に記載の光制御式光路切替型光信号伝送装置。
【請求項８】
３組以上の前記光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、連結の１段毎に前記鏡の穴を通って直進する方向と反射する方向の２方向に分岐し、多段に連結されていることを特徴とする請求項２に記載の光制御式光路切替型光信号伝送装置。
【請求項９】
３組以上の前記光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、連結の１段毎に前記鏡の穴を通って直進する方向と反射する方向の２方向に分岐し、多段に連結されていることを特徴とする請求項３に記載の光制御式光路切替型光信号伝送装置。
【請求項１０】
３組以上の前記光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、連結の１段毎に前記鏡の穴を通って直進する方向と反射する方向の２方向に分岐し、多段に連結されていることを特徴とする請求項４に記載の光制御式光路切替型光信号伝送装置。
【請求項１１】
１種類以上の波長の信号光と、前記信号光とは異なる２種類以上の波長の制御光とを、実質的に同軸かつ同方向に進行させ、
前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射し、
前記光吸収層膜を含む２つ以上の熱レンズ形成素子の個々において、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光の照射の有無に応じ、前記収束された信号光を収束させたまま出射させ、または、信号光の開き角度を可変させて出射させ、
反射面を有する穴付ミラーを用い、前記特定の１種類の波長の制御光の照射の有無に応じて、前記熱レンズ形成素子から出射した信号光を前記穴から通過直進させ、または、反射面で反射させることによって光路を変更させることを特徴とする光信号光路切替方法。
【請求項１２】

１種類以上の波長の信号光と、前記信号光とは異なる２種類以上の波長の制御光とを、実質的に同軸かつ同方向に進行させ、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射し、

前記光吸収層膜を含む２つ以上の熱レンズ形成素子の個々において、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されず前記光吸収層膜の入射面近傍に熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で前記熱レンズ形成素子から出射され、前記特定の１種類の波長の制御光が照射されて熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で前記熱レンズ形成素子から出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させ、

前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、穴付ミラーの穴に通過させ直進させ、

一方、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合は、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、あるいは、受光レンズによって前記開き角度を変更させた信号光のいずれかを、前記穴付ミラーの反射面を用いて反射することによって光路を変更させることを特徴とする光信号光路切替方法。

【請求項１３】

１種類以上の波長の信号光と、前記信号光とは異なる２種類以上の波長の制御光とを、実質的に同軸かつ同方向に進行させ、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射し、

前記光吸収層膜を含む２つ以上の熱レンズ形成素子の個々において、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は前記収束された信号光が収束されたまま前記熱レンズ形成素子から出射され、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で前記熱レンズ形成素子から出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させ、

前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は、収束されたまま前記熱レンズ形成素子から出射する前記収束された信号光を、穴付ミラーの穴に通過させ直進させ、

一方、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光の光路をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、前記穴付ミラーの反射面を用いて反射させることによって光路を変更させることを特徴とする光信号光路切替方法。

【請求項１４】

複数の波長の光の内、最も長い波長の光を信号光とし、信号光よりも短い２つ以上の波長の光を制御光とし、前記光路切替機構中の熱レンズ形成素子が吸収する波長が最も短い光路切替機構を第１段とし、第２段以降の前記光路切替機構の熱レンズ形成素子が吸収する各々の波長が長くなる順に後段の光路切替機構を連結することを特徴とする請求項２に記載の光制御式光路切替型光信号伝送装置。

【請求項１５】

複数の波長の光の内、最も長い波長の光を信号光とし、信号光よりも短い２つ以上の波長の光を制御光とし、前記光路切替機構中の熱レンズ形成素子が吸収する波長が最も短い光路切替機構を第１段とし、第２段以降の前記光路切替機構の熱レンズ形成素子が吸収する各々の波長が長くなる順に後段の光路切替機構を連結することを特徴とする請求項３に記載の光制御式光路切替型光信号伝送装置。

【請求項１６】

複数の波長の光の内、最も長い波長の光を信号光とし、信号光よりも短い２つ以上の波長の光を制御光とし、前記光路切替機構中の熱レンズ形成素子が吸収する波長が最も短い光路切替機構を第１段とし、第２段以降の前記光路切替機構の熱レンズ形成素子が吸収する各々の波長が長くなる順に後段の光路切替機構を連結することを特徴とする請求項４に記載の光制御式光路切替型光信号伝送装置。

【発明の詳細な説明】

【技術分野】

【０００１】

本発明は、光通信分野および光情報処理分野で用いられる光制御式光路切替型光信号伝送装置および光信号光路切替方法に関する。

【背景技術】

【０００２】

インターネットおよび会社内・家庭内イントラネットの普及にともなうネットワークトラフィックの爆発的増加に対応するため、電気信号を経由しない光路切替装置（光スイッチ）、すなわち、光－光直接スイッチが求められている。光ファイバー、光導波路、あるいは、空間を伝搬する光の進む道筋、すなわち、光路を切り替える装置・方法としては、例えば、光導波路内または光導波路間で光路を切り替える空間分割型、多重化された複数の波長の光を波長に応じた光路へ分割して切り替える波長分割多重型、一定時間毎に時分割多重化された光の光路を切り替える時分割多重型、空間を伝搬する光の光路を鏡やシャッターなどを用いて空間的に分割・合成するフリースペース型などの方式が知られている。これらの方式は、各々多重化することも複数を組み合わせて使用することもできる。

【０００３】

空間分割型光スイッチには、方向性結合器を利用するもの、光分岐器で光信号のコピーを作り、ゲート素子により光をオン・オフするもの、交差またはＹ分岐の交差部分で導波路の屈折率を変化させることで、導波路を伝搬してきた光を透過させたり反射させたりするものなどが提案されているが、まだ研究開発段階である。マッハツェンダー干渉計型光導波路スイッチの導波路の屈折率を変化させるために、電気ヒーター加熱による熱光学効果を用いるものが実用化に近づいているといわれているが、応答速度が１ミリ秒程度と遅いだけでなく、光スイッチを動作させるために電気信号を用いなければならない、という欠点を有する。

【０００４】

フリースペース型光スイッチには、マイクロ・エレクトロ・メカニカル・システム（Micro Electro Mechanical System;ＭＥＭＳと略記される）、励起子吸収・反射スイッチ（Exciton Absorption Reflection Switch；ＥＡＲＳスイッチと略記される）、多段ビームシフタ型光スイッチ、ホログラム型光スイッチ、液晶スイッチなどが検討されている。これらは、機械的可動部分がある、偏波依存性があるなどの課題があり、まだ充分実用段階にあるとはいえない。

【０００５】

一方、光学素子に光を照射することで引き起こされる透過率変化や屈折率変化を利用し、直接、光で光の強度や周波数を変調する、全光型光学素子や光制御方式の研究が盛んに行われている。本発明者らは、全光型光学素子等による新たな情報処理技術の開発を目指して、有機色素凝集体をポリマーマトリックスに分散した有機ナノパーティクル光熱レンズ形成素子（非特許文献１参照）を用いて、光制御方式の研究を行って来た。現在、制御

光（６３３ｎｍ）により信号光（７８０ｎｍ）の変調を行う方式で、制御光と信号光を同軸・同焦点入射させることを特徴とし、制御光の吸収により過渡的に形成される熱レンズにより信号光が屈折されるという動作原理の素子を開発しており、約２０ナノ秒の高速応答が達成されている。光応答性組成物からなる光学素子に制御光を照射し、制御光とは異なる波長帯域にある信号光の透過率および／または屈折率を可逆的に変化させることにより前記光学素子を透過する前記信号光の強度変調および／または光束密度変調を行う光制御方法であって、前記制御光および前記信号光を各々収束させて前記光学素子へ照射し、かつ、前記制御光および前記信号光のそれぞれの焦点の近傍（ビームウエスト）の光子密度が最も高い領域が前記光学素子中において互いに重なり合うように前記制御光および前記信号光の光路を調整することを特徴とする光制御方法が開示されている（特許文献１から特許文献７参照）。光応答性組成物からなる光学素子に、互いに波長の異なる制御光および信号光を照射し、前記制御光の波長は前記光応答性組成物が吸収する波長帯域から選ばれるものとし、前記光応答性組成物が前記制御光を吸収した領域およびその周辺領域に発生する温度上昇に起因する密度変化の分布に基づいた熱レンズを可逆的に形成させ、前記熱レンズを透過する信号光の強度変調および／または光束密度変調を行う光制御方法が開示されている（特許文献８参照）。そして、上記光学素子として例えば色素／樹脂膜や色素溶液膜が用いられ、制御光のパワー２ないし２５ｍＷにおける制御光照射に対する信号光の応答時間は、２マイクロ秒未満と記載されている（特許文献８参照）。

【０００６】

ここで熱レンズ効果とは、光吸収の中心部分において光を吸収した分子などが光を熱に変換し、この熱が周囲に伝搬されることにより温度分布が生じ、その結果、光透過媒体の屈折率が光吸収中心から外部へ向けて球状に変化して光吸収中心の屈折率が低く外部へ向けて屈折率が高くなる分布を生じ、これが凹レンズのように機能するような光の屈折効果を示す。熱レンズ効果は分光分析の分野で古くから利用されており、現在では分子１個による光吸収をも検出するような超高感度分光分析も可能になっている（非特許文献２および非特許文献３参照）。

【０００７】

熱レンズ効果ないし熱による屈折率変化を用いて光路を偏向させる方式として、発熱抵抗体で媒体に熱を与え、媒体内に屈折率分布を生じさせ、光を偏向する方法が開示されている（特許文献９参照）。しかしながら、上述の手法は、発熱抵抗体で発熱させ、熱伝導で媒体を加熱することになるので、「熱の拡がり」という問題を本来的に有する。つまり、熱の拡がりにより、広い面積内で微細な熱勾配を与えることができず、所望の屈折率分布を得るのが困難である。更に、発熱抵抗体の微細加工は半導体集積回路で用いられているフォトリソグラフィ技術を採用しても、現実には一定の限界を有し、素子が大型化せざるを得ない。素子が大型化すれば、それにともない光学系も複雑かつ大型化する。また、発熱抵抗体で発熱させ、熱伝導で媒体を加熱することになるので、応答が遅く、屈折率変化の周波数を上げることができないという不具合を本質的な問題として有している。

【０００８】

また、光応答組成物からなる光学素子と、該光学素子にくさび形の光強度分布で光を照射するための強度分布調整手段とから少なくとも構成され、制御光により前記光学素子中に屈折率分布を形成し、該屈折率分布により前記制御光とは異なる波長の信号光の偏向を行うことを特徴とする光学素子を用いた偏向素子が開示されている（特許文献１０参照）。この方式は、光で光を制御する点では優れたものであるが、偏向角度が３０度以内という制約があり、光路切替方向を自由に設定することができないという問題がある。

【０００９】

そこで本発明者らは、偏波依存性のない、光路切替の角度および方向を自由に設定可能な、信号光の光強度減衰が少なく多重連結使用が可能な光路切替装置および光路切替方法を提供するため、少なくとも光吸収層膜を含む熱レンズ形成素子中の光吸収層膜に、前記光吸収層膜が吸収する波長帯域から選ばれる波長の制御光、および、前記光吸収層膜が吸収しない波長帯域から選ばれる波長の信号光を各々収束させて照射し、少なくとも前記制

御光が前記光吸収層膜内において焦点を結ぶように配置を調整し、前記光吸収層膜が前記制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で前記熱レンズ形成素子から出射する状態と、制御光が照射されて熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で前記熱レンズ形成素子から出射する状態とを、前記制御光の照射の有無に対応させて実現させ、制御光が照射されず熱レンズが形成されない場合は、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記通常の開き角度を変更させた後、前記信号光が通過する穴を設けた鏡の穴を通して直進させ、一方、制御光が照射されて熱レンズが形成される場合は、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、あるいは、受光レンズによって前記拡がりの開き角度を変更させた後、前記穴付ミラーを用いて反射することによって光路を変更させる光路切替方法を出願した（特許文献１１参照）。

【００１０】

【特許文献１】特開平８－２８６２２０号公報
【特許文献２】特開平８－３２０５３５号公報
【特許文献３】特開平８－３２０５３６号公報
【特許文献４】特開平９－３２９８１６号公報
【特許文献５】特開平１０－９０７３３号公報
【特許文献６】特開平１０－９０７３４号公報
【特許文献７】特開平１０－１４８８５２号公報
【特許文献８】特開平１０－１４８８５３号公報
【特許文献９】特開昭６０－１４２２１号公報
【特許文献１０】特開平１１－１９４３７３号公報
【特許文献１１】特願２００２－２７５７１３号
【非特許文献１】平賀隆、田中教雄、早水紀久子、守谷哲郎著、色素会合体・凝集体の作成・構造評価・光物性、「電子技術総合研究所彙報」、通商産業省工業技術院電子技術総合研究所発行、第５９巻、第２号、２９－４９頁（１９９４年）
【非特許文献２】藤原祺多夫、不破敬一郎、小林孝嘉著、レーザー誘起熱レンズ効果とその比色法への応用、「化学」、化学同人発行、第３６巻、第６号、４３２－４３８頁（１９８１年）
【非特許文献３】北森武彦、澤田嗣郎著、光熱変換分光分析法、「ぶんせき」、日本分析化学会発行、１９９４年3月号、１７８－１８７頁

【発明の開示】

【発明が解決しようとする課題】

【００１１】

本発明は、電気回路や機械的可動部分を用いずに故障のない、高速で作動し、耐久性の高い、偏波依存性のない、光制御式光路切替型光信号伝送装置および光信号光路切替方法を提供することを目的とする。

【課題を解決するための手段】

【００１２】

上記の目的を達成するため、本発明の光制御式光路切替型光信号伝送装置は、１種類以上の波長の信号光を照射する信号光光源と、

前記信号光とは異なる２種類以上の波長の制御光を照射する制御光光源と、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、

前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、

前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した

領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光の照射の有無に応じ、前記収束された信号光を収束させたまま出射する、または、信号光の開き角度を可変させて出射する２つ以上の熱レンズ形成素子と、

前記各熱レンズ形成素子の各々後方に設けられた、穴と反射手段とを有する鏡であって、前記特定の１種類の波長の制御光の照射の有無に応じて、前記熱レンズ形成素子を出射した信号光を前記穴に通過させ、または、前記反射手段により反射させることによって光路を変化させる鏡と、を備えることを特徴とする。

【００１３】

また、本発明の他の光制御式光路切替型光信号伝送装置は、１種類以上の波長の信号光を照射する信号光光源と、

前記信号光とは異なる２種類以上の波長の制御光を照射する制御光光源と、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、

前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、

熱レンズ形成素子と穴を有する鏡の組み合わせからなる２組以上の光路切替機構と、を備え、

前記熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、

前記穴を有する鏡は、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、通過させる穴と、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合に、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、または、前記受光レンズによって前記開き角度を変更させた信号光のいずれかを、反射する反射手段と、を有し光路を変更させる鏡であることを特徴とする。

【００１４】

また、本発明の他の光制御式光路切替型光信号伝送装置は、１種類以上の波長の信号光を照射する信号光光源と、

前記信号光とは異なる２種類以上の波長の制御光を照射する制御光光源と、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、

前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、

熱レンズ形成素子と穴を有する鏡の組み合わせからなる２組以上の光路切替機構と、を備え、

前記熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は前記収束された信号光が収束されたまま出射され、制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制

御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、

前記穴を有する鏡は、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合に、収束されたまま前記熱レンズ形成素子から出射する前記収束された信号光を通過させる穴と、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、前記開き角度を変更させるために設けられた受光レンズを透過させた信号光のいずれかを反射させる反射手段と、を有し光路を変更させる鏡であることを特徴とする。

【００１５】

また、本発明の他の光制御式光路切替型光信号伝送装置は、１種類以上の波長の信号光を照射する信号光光源と、

前記信号光とは異なる２種類以上の波長の制御光を制御する制御光光源と、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜と、

前記光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射する手段と、

第１の熱レンズ形成素子と第１の穴を有する鏡との組み合わせからなる１組以上の第１の光路切替機構と、

第２の熱レンズ形成素子と第２の穴を有する鏡との組み合わせからなる１組以上の第２の光路切替機構と、を備え、

第１の熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、

第１の穴を有する鏡は、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、通過させる穴と、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合に、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、または、前記受光レンズによって前記開き角度を変更させた信号光のいずれかを、反射する反射手段と、を有し光路を変更させる鏡であり、

第２の熱レンズ形成素子は、前記光吸収層膜を含み、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は前記収束された信号光が収束されたまま出射され、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させる熱レンズ形成素子であり、

第２の穴を有する鏡は、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合に、収束されたまま前記熱レンズ形成素子から出射する前記収束された信号光を通過させる穴と、前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合に、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、前記開き角度を変更させるために設けられた受光

レンズを透過させた信号光のいずれかを反射させる反射手段と、を有し光路を変更させる鏡である光制御式光路切替型光信号伝送装置。

【００１６】

また、本発明の他の光制御式光路切替型光信号伝送装置は、２組以上の上述の光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、直列に連結されていることを特徴とする。

【００１７】

また、本発明の他の光制御式光路切替型光信号伝送装置は、３組以上の上述の光路切替機構が、空間を介して直接、または、光ファイバー結合系を介して、連結の１段毎に前記鏡の穴を通って直進する方向と反射する方向の２方向に分岐し、多段に連結されていることを特徴とする。

【００１８】

また、本発明の光信号光路切替方法は、

１種類以上の波長の信号光と、前記信号光とは異なる２種類以上の波長の制御光とを、実質的に同軸かつ同方向に進行させ、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射し、

前記光吸収層膜を含む２つ以上の熱レンズ形成素子の個々において、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光の照射の有無に応じ、前記収束された信号光を収束させたまま出射させ、または、信号光の開き角度を可変させて出射させ、

反射面を有する穴付ミラーを用い、前記特定の１種類の波長の制御光の照射の有無に応じて、前記熱レンズ形成素子から出射した信号光を前記穴から通過直進させ、または、反射面で反射させることによって光路を変更させることを特徴とする。

【００１９】

また、本発明の他の光信号光路切替方法は、

１種類以上の波長の信号光と、前記信号光とは異なる２種類以上の波長の制御光とを、実質的に同軸かつ同方向に進行させ、

前記信号光は透過し、前記制御光の特定の１種類の波長のみを各々選択的に吸収する２つ以上の光吸収層膜の１つ１つに前記制御光と前記信号光とを各々収束させて照射し、

前記光吸収層膜を含む２つ以上の熱レンズ形成素子の個々において、前記光吸収層膜が前記特定の１種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の１種類の波長の制御光が照射されず前記光吸収層膜の入射面近傍に熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で前記熱レンズ形成素子から出射され、前記特定の１種類の波長の制御光が照射されて熱レンズが形成される場合は前記収束された信号光が通常の開き角度よりも大きい開き角度で前記熱レンズ形成素子から出射され、前記特定の１種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させ、

前記特定の１種類の波長の制御光が照射されず熱レンズが形成されない場合は、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、穴付ミラーの穴に通過させ直進させ、

一方、前記特定の１種類の波長の制御光が照射されて前記光吸収層膜の入射面近傍に熱レンズが形成される場合は、通常よりも大きい開き角度で前記熱レンズ形成素子から拡がりながら出射する前記信号光をそのまま、あるいは、受光レンズによって前記開き角度を変更させた信号光のいずれかを、前記穴付ミラーの反射面を用いて反射することによって光路を変更させることを特徴とする。

【００２０】

また、本発明の他の光信号光路切替方法は、
1種類以上の波長の信号光と、前記信号光とは異なる2種類以上の波長の制御光とを、実質的に同軸かつ同方向に進行させ、
前記信号光は透過し、前記制御光の特定の1種類の波長のみを各々選択的に吸収する2つ以上の光吸収層膜の1つ1つに前記制御光と前記信号光とを各々収束させて照射し、
前記光吸収層膜を含む2つ以上の熱レンズ形成素子の個々において、前記光吸収層膜が前記特定の1種類の波長の制御光を吸収した領域およびその周辺領域に起こる温度上昇に起因して可逆的に生ずる屈折率の分布に基づいた熱レンズを用いることによって、前記特定の1種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は前記収束された信号光が収束されたまま前記熱レンズ形成素子から出射され、前記特定の1種類の波長の制御光が照射されず熱レンズが形成されない場合は前記収束された信号光が通常の開き角度で前記熱レンズ形成素子から出射され、前記特定の1種類の波長の制御光の照射の有無に応じて出射される前記信号光の開き角度を変更させ、
前記特定の1種類の波長の制御光が照射されて前記光吸収層膜の出射面近傍に熱レンズが形成される場合は、収束されたまま前記熱レンズ形成素子から出射する前記収束された信号光を、穴付ミラーの穴に通過させ直進させ、
一方、前記特定の1種類の波長の制御光が照射されず熱レンズが形成されない場合は、通常の開き角度で前記熱レンズ形成素子から出射する前記信号光の光路をそのまま、または、受光レンズによって前記開き角度を変更させた信号光のいずれかを、前記穴付ミラーの反射面を用いて反射させることによって光路を変更させることを特徴とする。
【0021】
また、本発明の他の光制御式光路切替型光信号伝送装置は、
複数の波長の光の内、最も長い波長の光を信号光とし、信号光よりも短い2つ以上の波長の光を制御光とし、前記光路切替機構中の熱レンズ形成素子が吸収する波長が最も短い光路切替機構を第1段とし、第2段以降の前記光路切替機構の熱レンズ形成素子が吸収する各々の波長が長くなる順に後段の光路切替機構を連結することを特徴とする。
【発明の効果】
【0022】
本発明によって、電気回路や機械的可動部分を用いずに、高速で作動し、耐久性の高い、偏波依存性のない、光制御式光路切替型光信号伝送装置および光信号光路切替方法を提供することができる。
【発明を実施するための最良の形態】
【0023】
［熱レンズ形成素子］
本発明において、熱レンズ形成素子としては例えば積層膜型構造を有するものを好適に用いることができ、その積層膜の構成としては例えば以下のような組み合わせを挙げることができる。
【0024】
（1）光吸収層膜単独。ただし、光吸収層膜は、文字通り「光吸収膜」単独の単層膜、あるいは、「光吸収膜／熱レンズ形成層」という2層構造、または、「光吸収膜／熱レンズ形成層／光吸収膜」という3層構造の積層型薄膜のいずれであっても良い。なお、以下の（2）から（10）の「光吸収層膜」も上記同様の構造を含むものとする。
【0025】
（2）光吸収層膜／保温層膜
【0026】
（3）保温層膜／光吸収層膜／保温層膜
【0027】
（4）光吸収層膜／伝熱層膜
【0028】
（5）伝熱層膜／光吸収層膜／伝熱層膜

【００２９】
（６）光吸収層膜／保温層膜／伝熱層膜
【００３０】
（７）伝熱層膜／光吸収層膜／保温層膜
【００３１】
（８）伝熱層膜／光吸収層膜／保温層膜／伝熱層膜
【００３２】
（９）伝熱層膜／保温層膜／光吸収層膜／保温層膜
【００３３】
（１０）伝熱層膜／保温層膜／光吸収層膜／保温層膜／伝熱層膜
【００３４】
（１１）屈折率分布型レンズ／（光透過層／）上記（１）ないし（１０）の熱レンズ形成素子
【００３５】
（１２）屈折率分布型レンズ／（光透過層／）上記（１）ないし（１０）の熱レンズ形成素子／（光透過層／）屈折率分布型レンズ
【００３６】
なお、上記「（光透過層／）」とは、必要に応じて光透過層を設けることを意味する。更に、必要に応じて光の入射面および出射面に反射防止膜（ＡＲコート膜）を設けても良い。
【００３７】
熱レンズ形成素子構成の一例を例示した断面図を図１１に示す。図１１に例示するように、熱レンズ形成素子５００は、制御光５０９および信号光５０８の入射側から、例えば、屈折率分布型レンズ５０７／光透過層５０６／伝熱層膜５０１／光吸収層膜５０３／熱レンズ形成層５０５／光吸収層膜５０４／伝熱層膜５０２の順に積層されてなる。なお、図１１に示す制御光５０９の光線は模式的なものであり、各層膜間における屈折を省略している。
【００３８】
熱レンズ形成素子構成の別の一例を例示した断面図を図１２に示す。図１２に例示するように、熱レンズ形成素子６００は、制御光６０９および信号光６０８の入射側から、例えば、伝熱層膜６０１／光吸収層膜６０３／熱レンズ形成層６０５／光吸収層膜６０４／伝熱層膜６０２の順に積層されてなる。この場合、制御光６０９および信号光６０８は外部に設けた集光レンズ６１０によって集光されつつ、熱レンズ形成素子６００に入射する。なお、図１２に示す制御光６０９の光線は模式的なものであり、各層膜間における屈折を省略している。
【００３９】
更にまた、色素溶液充填式熱レンズ形成素子を例示した模式図を図２１に示す。図２１に例示するように、色素溶液充填式熱レンズ形成素子８００は、伝熱層膜として作用する入射・出射面ガラス８０１および８０２、側面ガラス８０３および８０４、底面ガラス８０５に囲まれた光学セル８０９の色素溶液充填部８０８へ、導入管８０６の導入口８０７から光吸収層膜兼熱レンズ形成層として作用する色素溶液を充填し、導入口８０７を封じたものである。すなわち、伝熱層膜／光吸収層膜兼熱レンズ形成層／伝熱層膜という単純な素子構成のものである。
【００４０】
光吸収層膜、熱レンズ形成層、保温層膜、伝熱層膜、光透過層、および屈折率分布型レンズの材料、作成方法、各々の膜厚などについて、以下に、順を追って説明する。
【００４１】
なお、本発明で用いられる光吸収層膜、熱レンズ形成層、保温層膜、伝熱層膜、光透過層、および屈折率分布型レンズの材料は、その機能に支障をきたさない範囲において、加工性を向上させたり、光学素子としての安定性・耐久性を向上させたりするため、添加物

として公知の酸化防止剤、紫外線吸収剤、一重項酸素クエンチャー、分散助剤などを含有しても良い。

【0042】

［光吸収層膜の材料］

本発明で用いられる熱レンズ形成素子中の光吸収層膜に用いられる光吸収性の材料としては、公知の種々のものを使用することができる。

【0043】

本発明で用いられる熱レンズ形成素子中の光吸収層膜に用いられる光吸収性材料の例を具体的に挙げるならば、例えば、ＧａＡｓ、ＧａＡｓＰ、ＧａＡｌＡｓ、ＩｎＰ、ＩｎＳｂ、ＩｎＡｓ、ＰｂＴｅ、ＩｎＧａＡｓＰ、ＺｎＳｅなどの化合物半導体の単結晶、前記化合物半導体の微粒子をマトリックス材料中へ分散したもの、異種金属イオンをドープした金属ハロゲン化物（例えば、臭化カリウム、塩化ナトリウムなど）の単結晶、前記金属ハロゲン化物（例えば、臭化銅、塩化銅、塩化コバルトなど）の微粒子をマトリックス材料中へ分散したもの、銅などの異種金属イオンをドープしたＣｄＳ、ＣｄＳｅ、ＣｄＳｅＳ、ＣｄＳｅＴｅなどのカドミウムカルコゲナイドの単結晶、前記カドミウムカルコゲナイドの微粒子をマトリックス材料中に分散したもの、シリコン、ゲルマニウム、セレン、テルルなどの半導体単結晶薄膜、多結晶薄膜ないし多孔質薄膜、シリコン、ゲルマニウム、セレン、テルルなどの半導体微粒子をマトリックス材料中へ分散したもの、ルビー、アレキサンドライト、ガーネット、Ｎｄ：ＹＡＧ、サファイア、Ｔｉ：サファイア、Ｎｄ：ＹＬＦなど、金属イオンをドープした宝石に相当する単結晶（いわゆるレーザー結晶）、金属イオン（例えば、鉄イオン）をドープしたニオブ酸リチウム（$LiNbO_3$）、LiB_3O_5、$LiTaO_3$、$KTiOPO_4$、KH_2PO_4、$KNbO_3$、BaB_2O_2などの強誘電性結晶、金属イオン（例えば、ネオジウムイオン、エルビウムイオンなど）をドープした石英ガラス、ソーダガラス、ホウケイ酸ガラス、その他のガラスなどのほか、マトリックス材料中に色素を溶解または分散したもの、および、非晶質の色素凝集体を好適に使用することができる。

【0044】

これらの中でも、マトリックス材料中に色素を溶解または分散したものは、マトリックス材料および色素の選択範囲が広く、かつ熱レンズ形成素子への加工も容易であるため、特に好適に用いることができる。

【0045】

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いることができる色素の具体例としては、例えば、ローダミンＢ、ローダミン６Ｇ、エオシン、フロキシンＢなどのキサンテン系色素、アクリジンオレンジ、アクリジンレッドなどのアクリジン系色素、エチルレッド、メチルレッドなどのアゾ色素、ポルフィリン系色素、フタロシアニン系色素、ナフタロシアニン系色素、３，３’－ジエチルチアカルボシアニンヨージド、３，３’－ジエチルオキサジカルボシアニンヨージドなどのシアニン色素、エチル・バイオレット、ビクトリア・ブルーＲなどのトリアリールメタン系色素、ナフトキノン系色素、アントラキノン系色素、ナフタレンテトラカルボン酸ジイミド系色素、ペリレンテトラカルボン酸ジイミド系色素などを好適に使用することができる。

【0046】

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法では、これらの色素を単独で、または、２種以上を混合して使用することができる。

【0047】

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いることのできるマトリックス材料は、

（１）本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いられる光の波長領域で透過率が高いこと、

（２）本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いられる色素または種々の微粒子を安定性良く溶解または分散できること、

という条件を満足するものであれば任意のものを使用することができる。

【００４８】

無機系固体状のマトリックス材料としては、例えば金属ハロゲン化物の単結晶、金属酸化物の単結晶、金属カルコゲナイドの単結晶、石英ガラス、ソーダガラス、ホウケイ酸ガラスなどの他、いわゆるゾルゲル法で作成された低融点ガラス材料などを使用することができる。

【００４９】

無機系液体状のマトリックス材料としては、水、水ガラス（アルカリケイ酸塩の濃厚水溶液）、塩酸、硫酸、硝酸、王水、クロルスルホン酸、メタンスルホン酸、トリフルオロメタンスルホン酸、などを使用することができる。

【００５０】

また、有機系液体状のマトリックス材料として、例えば種々の有機溶剤を使用することができる。有機溶剤としては、具体的には、メタノール、エタノール、イソプロピルアルコール、ｎ－ブタノール、アミルアルコール、シクロヘキサノール、ベンジルアルコールなどのアルコール類、エチレングリコール、ジエチレングリコール、グリセリンなどの多価アルコール類、酢酸エチル、酢酸ｎ－ブチル、酢酸アミル、酢酸イソプロピルなどのエステル類、アセトン、メチルエチルケトン、メチルイソブチルケトン、シクロヘキサノンなどのケトン類、ジエチルエーテル、ジブチルエーテル、メトキシエタノール、エトキシエタノール、ブトキシエタノール、カルビトールなどのエーテル類、テトラヒドロフラン、１、４－ジオキサン、１、３－ジオキソラン、などの環状エーテル類、ジクロロメタン、クロロホルム、四塩化炭素、１、２－ジクロロエタン、１、１、２－トリクロロエタン、トリクレン、ブロモホルム、ジブロモメタン、ジヨードメタン、などのハロゲン化炭化水素類、ベンゼン、トルエン、キシレン、クロロベンゼン、ｏ－ジクロロベンゼン、ニトロベンゼン、アニソール、α－クロロナフタレンなどの芳香族炭化水素類、ｎ－ペンタン、ｎ－ヘキサン、ｎ－ヘプタン、シクロヘキサンなどの脂肪族炭化水素類、Ｎ，Ｎ－ジメチルホルムアミド、Ｎ，Ｎ－ジメチルアセトアミド、ヘキサメチルホスホリックトリアミドなどのアミド類、Ｎ－メチルピロリドンなどの環状アミド類、テトラメチル尿素、１、３－ジメチル－２－イミダゾリジノンなどの尿素誘導体類、ジメチルスルホキシドなどのスルホキシド類、炭酸エチレン、炭酸プロピレンなどの炭酸エステル類、アセトニトリル、プロピオニトリル、ベンゾニトリルなどのニトリル類、ピリジン、キノリンなどの含窒素複素環化合物類、トリエチルアミン、トリエタノールアミン、ジエチルアミノアルコール、アニリンなどのアミン類、クロル酢酸、トリクロル酢酸、トリフルオロ酢酸、酢酸などの有機酸の他、ニトロメタン、二硫化炭素、スルホランなどの溶剤を用いることができる。これらの溶剤は、また、複数の種類のものを混合して用いても良い。

【００５１】

更に、有機系のマトリックス材料として、液体状、固体状、ガラス状またはゴム状の有機高分子材料を使用することができる。その具体例としては、ポリスチレン、ポリ（α－メチルスチレン）、ポリインデン、ポリ（４－メチル－１－ペンテン）、ポリビニルピリジン、ポリビニルホルマール、ポリビニルアセタール、ポリビニルブチラール、ポリ酢酸ビニル、ポリビニルアルコール、ポリ塩化ビニル、ポリ塩化ビニリデン、ポリビニルメチルエーテル、ポリビニルエチルエーテル、ポリビニルベンジルエーテル、ポリビニルメチルケトン、ポリ（Ｎ－ビニルカルバゾール）、ポリ（Ｎ－ビニルピロリドン）、ポリアクリル酸メチル、ポリアクリル酸エチル、ポリアクリル酸、ポリアクリロニトリル、ポリメタクリル酸メチル、ポリメタクリル酸エチル、ポリメタクリル酸ブチル、ポリメタクリル酸ベンジル、ポリメタクリル酸シクロヘキシル、ポリメタクリル酸、ポリメタクリル酸アミド、ポリメタクリロニトリル、ポリアセトアルデヒド、ポリクロラール、ポリエチレンオキシド、ポリプロピレンオキシド、ポリエチレンテレフタレート、ポリブチレンテレフタレート、ポリカーボネート類（ビスフェノール類＋炭酸）、ポリ（ジエチレングリコール・ビスアリルカーボネイト）類、６－ナイロン、６，６－ナイロン、１２－ナイロン、６，１２－ナイロン、ポリアスパラギン酸エチル、ポリグルタミン酸エチル、ポリリジン

、ポリプロリン、ポリ（γ－ベンジル－Ｌ－グルタメート）、メチルセルロース、エチルセルロース、ベンジルセルロース、ヒドロキシエチルセルロース、ヒドロキシプロピルセルロース、アセチルセルロース、セルローストリアセテート、セルローストリブチレート、アルキド樹脂（無水フタル酸＋グリセリン）、脂肪酸変性アルキド樹脂（脂肪酸＋無水フタル酸＋グリセリン）、不飽和ポリエステル樹脂（無水マレイン酸＋無水フタル酸＋プロピレングリコール）、エポキシ樹脂（ビスフェノール類＋エピクロルヒドリン）、ポリウレタン樹脂、フェノール樹脂、尿素樹脂、メラミン樹脂、キシレン樹脂、トルエン樹脂、グアナミン樹脂などの樹脂、ポリ（フェニルメチルシラン）などの有機ポリシラン、有機ポリゲルマンおよびこれらの共重合・共重縮合体が挙げられる。また、二硫化炭素、四フッ化炭素、エチルベンゼン、パーフルオロベンゼン、パーフルオロシクロヘキサンまたはトリメチルクロロシラン等、通常では重合性のない化合物をプラズマ重合して得た高分子化合物などを使用することができる。更に、これらの有機高分子化合物に色素の残基をモノマー単位の側鎖として、もしくは架橋基として、共重合モノマー単位として、または重合開始末端として結合させたものをマトリックス材料として使用することもできる。更に、前記の色素残基とマトリックス材料が化学結合を形成していても良い。

【００５２】

これらのマトリックス材料中へ色素を溶解または分散させるには公知の方法を用いることができる。例えば、色素とマトリックス材料を共通の溶媒中へ溶解して混合した後、溶媒を蒸発させて除去する方法、ゾルゲル法で製造する無機系マトリックス材料の原料溶液へ色素を溶解または分散させてからマトリックス材料を形成する方法、有機高分子系マトリックス材料のモノマー中へ、必要に応じて溶媒を用いて、色素を溶解または分散させてから該モノマーを重合ないし重縮合させてマトリックス材料を形成する方法、色素と有機高分子系マトリックス材料を共通の溶媒中に溶解した溶液を、色素および熱可塑性の有機高分子系マトリックス材料の両方が不溶の溶剤中へ滴下し、生じた沈殿を濾別し乾燥してから加熱・溶融加工する方法などを好適に用いることができる。色素とマトリックス材料の組み合わせおよび加工方法を工夫することで、色素分子を凝集させ、「Ｈ会合体」や「Ｊ会合体」などと呼ばれる特殊な会合体を形成させられることが知られているが、マトリックス材料中の色素分子をこのような凝集状態もしくは会合状態を形成する条件で使用しても良い。

【００５３】

また、これらのマトリックス材料中へ前記の種々の微粒子を分散させるには公知の方法を用いることができる。例えば、前記微粒子をマトリックス材料の溶液、または、マトリックス材料の前駆体の溶液に分散した後、溶媒を除去する方法、有機高分子系マトリックス材料のモノマー中へ、必要に応じて溶媒を用いて、前記微粒子を分散させてから該モノマーを重合ないし重縮合させてマトリックス材料を形成する方法、微粒子の前駆体として、例えば過塩素酸カドミウムや塩化金などの金属塩を有機高分子系マトリックス材料中へ溶解または分散した後、硫化水素ガスで処理して硫化カドミウムの微粒子を、または、熱処理することで金の微粒子を、それぞれマトリックス材料中に析出させる方法、化学的気相成長法、スパッタリング法などを好適に用いることができる。

【００５４】

色素を単独で、光散乱の少ない非晶質状態（アモルファス）の薄膜として存在させることができる場合は、マトリックス材料を用いずに、非晶質色素膜を光吸収層膜として用いることもできる。

【００５５】

また、色素を単独で、光散乱を起こさない微結晶凝集体として存在させることができる場合は、マトリックス材料を用いずに、色素の微結晶凝集体を光吸収層膜として用いることもできる。本発明で用いられる熱レンズ形成素子におけるように、光吸収層膜としての色素微結晶凝集体が、熱レンズ形成層（樹脂など）、伝熱層膜（ガラスなど）および／または保温層膜（樹脂など）と積層されて存在する場合、前記色素微小結晶の粒子径が前記信号光の波長と制御光の波長を比べて短い方の波長の１／５を超えない大きさであれば、

実質的に光散乱を起こさない。

【００５６】

［光吸収層膜の材料、信号光の波長帯域、および、制御光の波長帯域の組み合わせと順序］

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で使用される光吸収層膜の材料、信号光の波長帯域、および制御光の波長帯域は、これらの組み合わせとして、使用目的に応じて適切な組み合わせを選定し用いることができる。

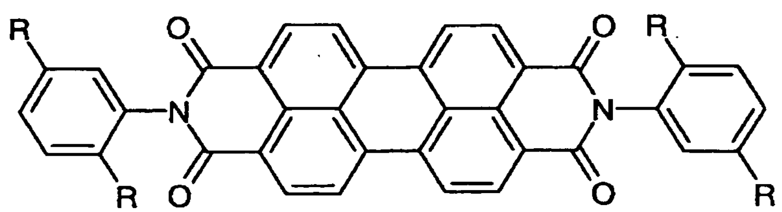
【００５７】

具体的な設定手順としては、例えば、まず、使用目的に応じて信号光の波長ないし波長帯域を決定し、これを制御するのに最適な光吸収層膜の材料と制御光の波長の組み合わせを選定すれば良い。または、使用目的に応じて信号光と制御光の波長の組み合わせを決定してから、この組み合わせに適した光吸収層膜の材料を選定すれば良い。

【００５８】

このような選定手順の具体例として、信号光としてギガヘルツオーダーで超高速変調可能な半導体レーザーから発振する波長８５０ｎｍ、１３５０ｎｍあるいは１５５０ｎｍなどの近赤外線を用い、これを、複数の可視光線波長帯域の制御光で光路切替するケースを以下に例示する。制御光の光源としてはサブミリ秒以下の応答速度で断続可能な連続（ＣＷ）発振方式のレーザーを好適に用いることができる。例えば、短波長側から、４０５ないし４４５ｎｍの青紫ないし青色半導体レーザー、半導体励起Ｎｄ：ＹＡＧレーザーの波長１０６４ｎｍを２次非線形光学素子で５３２ｎｍの緑色に変換したもの、６３５ないし６７０ｎｍの赤色半導体レーザー、および、７８０ないし８００ｎｍの近赤外線レーザーを選定し、好適に使用することができる。これらの制御光波長帯域に吸収を示し、８５０ｎｍないし１５５０ｎｍの近赤外線を吸収しない色素として、例えば、Ｎ，Ｎ’－ビス（２，５－ジ－tert－ブチルフェニル）－３，４，９，１０－ペリレンジカルボキシイミド(N,N'-Bis(2,5-di-tert-butylphenyl)-3,4,9,10-perylenedicarboxlmide)〔１〕、

【化１】

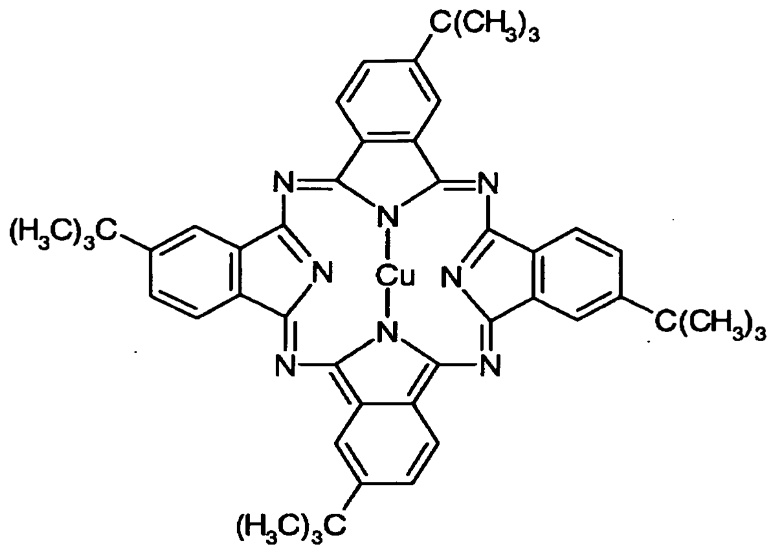


…〔1〕

[R = $C(CH_3)_3$]

銅(II)２，９，１６，２３－テトラ－tert－ブチル－２９Ｈ，３１Ｈ－フタロシアニン(Copper(II)2,9,16,23-tetra-tert-butyl-29H,31H-phthalocyanine)〔２〕、

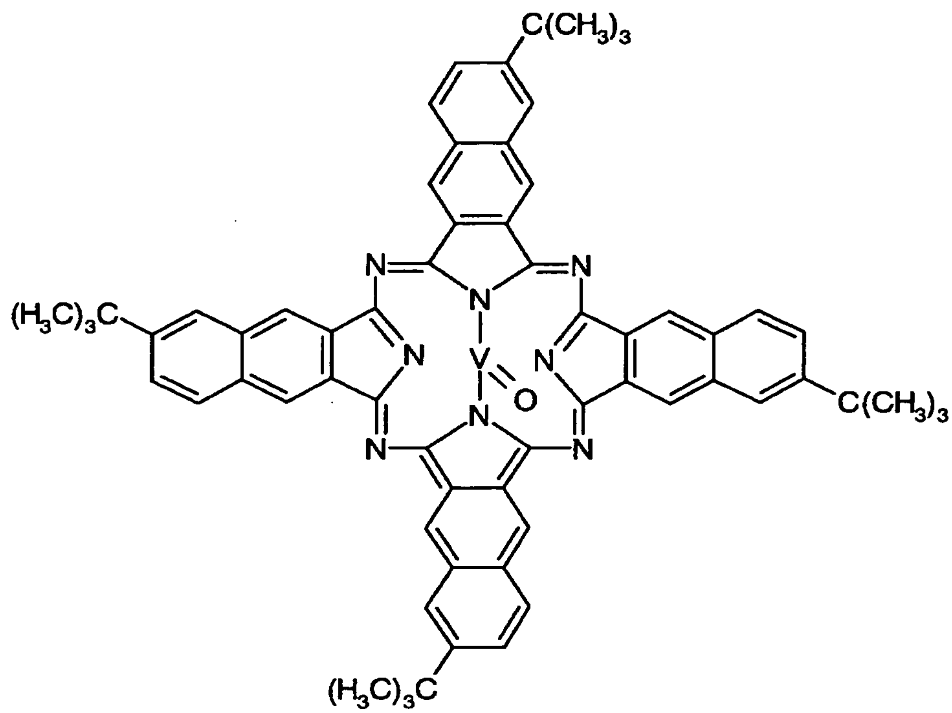
【化２】



…〔２〕

バナジル２，１１，２０，２９－テトラ－tert－ブチル－２，３－ナフタロシアニン（Vanadyl 2,11,20,29-tetra-tert-butyl-2,3-naphthalocyanine）〔３〕、

【化３】



…〔３〕

などを２つ以上選定して、各々好適に使用することができる。これらの色素はいずれも耐光性および耐熱性が高く、本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法において熱レンズ形成のための光吸収層膜用の色素として特に好適である。色素〔１〕、〔２〕および〔３〕のテトラヒドロフラン溶液の透過率スペクトルを図２２に各々実線、鎖線および一点鎖線で示す。図２２には示していないが、これらの色素溶液は９００ないし１５５０ｎｍの近赤外線領域においても９８％以上の透過率を示す。

【００５９】

前記制御光レーザーの発振波長と、これら色素の透過率スペクトルとの関係を表１に示す。

【００６０】

【表１】

	色素番号	レーザー発振波長［nm］							
		445	532	635	650	670	780	800	850
透過率[%]	〔1〕	3.59	0.10	97.08	97.36	97.33	97.67	97.15	98.64
	〔2〕	93.64	81.67	2.32	0.78	0.00	97.23	98.37	99.63
	〔3〕	52.19	89.90	88.72	81.56	73.35	9.06	0.12	89.00

【００６１】

表１から判るように、色素〔１〕は波長４４５ないし５３２ｎｍの制御光を吸収して熱レンズを形成するような熱レンズ形成素子の光吸収層膜の材料として好適である。同様に色素〔２〕は波長６３５ないし６７０ｎｍに対応する光吸収層膜の材料として、また、色素〔３〕は波長７８０ないし８００ｎｍに対応する光吸収層膜の材料として好適である。これらの色素は前記溶剤に溶解させて光学セルへ充填し、または有機高分子材料中に溶解させて伝熱層膜に挟んで、あるいは、伝熱層膜上にスピンコート膜または蒸着膜として成膜して、使用することができる。

【００６２】

これらの色素を２種類以上選択して使用する場合、各々の色素の吸収波長帯域に対応する熱レンズ形成素子を含む光路切替機構を、吸収波長帯域の短い方から順に連結して使用することが好ましい。すなわち、例えば、第１段目の光路切替機構に色素〔１〕、第２段目に色素〔２〕または〔３〕の２段構成、第１段目に色素〔１〕、第２段目に色素〔２〕、第３段目に色素〔３〕の３段構成として使用することで、各色素の吸収帯域と非吸収帯域を無駄なく重ねて利用することが可能である。

【００６３】

［光吸収層膜の材料の組成、光吸収層膜中の光吸収層膜の膜厚、および熱レンズ形成層の膜厚］

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いられる熱レンズ形成素子において、光吸収層膜は、「光吸収膜」単独の単層膜、あるいは、「光吸収膜／熱レンズ形成層」という２層構造、または、「光吸収膜／熱レンズ形成層／光吸収膜」という３層構造の積層型薄膜のいずれであっても良く、光吸収層膜全体の厚さは、収束された前記制御光の共焦点距離の２倍を超えないことが好ましい。更に、一層高速な応答速度を目指す場合は、前記積層型薄膜からなる光吸収層膜の厚さは、収束された前記制御光の共焦点距離の１倍を超えないことが好ましい。

【００６４】

このような条件の中で、本発明で用いられる光吸収層膜の材料の組成および光吸収層膜中の光吸収膜（１または２枚）の膜厚については、これらの組み合わせとして、光吸収層膜を透過する制御光および信号光の透過率を基準にして設定することができる。例えば、まず、光吸収層膜の材料の組成の内、少なくとも制御光あるいは信号光を吸収する成分の濃度を決定し、次いで、熱レンズ形成素子を透過する制御光および信号光の透過率が特定の値になるよう光吸収層膜中の光吸収膜（１または２枚）の膜厚を設定することができる。または、まず、例えば装置設計上の必要に応じて、光吸収層膜中の光吸収膜（１または２枚）の膜厚を特定の値に設定した後、熱レンズ形成素子を透過する制御光および信号光の透過率が特定の値になるよう光吸収層膜の材料の組成を調整することができる。

【００６５】

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いられる熱レンズ形成素子から、できる限り低い光パワーで充分な大きさおよび高速度の熱レンズ効

果を引き出すために最適な、光吸収層膜を透過する制御光および信号光の透過率の値は、それぞれ、次に示す通りである。
【００６６】
本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法で用いられる熱レンズ形成素子においては、熱レンズ形成素子中の光吸収層膜を伝播する制御光の透過率が９０％ないし０％になるよう光吸収層膜中の光吸収成分の濃度および存在状態の制御、光吸収層膜中の光吸収膜（１または２枚）の膜厚設定を行うことが推奨される。
【００６７】
一方、制御光を照射しない状態において、熱レンズ形成素子中の光吸収層膜を伝播する信号光の透過率が下限として１０％以上、また、上限としては１００％に限りなく近づくよう光吸収層膜中の光吸収成分の濃度および存在状態の制御、光吸収層膜中の光吸収膜（１または２枚）の膜厚設定を行うことが推奨される。
【００６８】
光吸収層膜中の熱レンズ形成層膜厚の下限は、以下に記載するように、熱レンズ形成層の材料に応じて選定される。
【００６９】
［光吸収層膜中の熱レンズ形成層の材料および熱レンズ形成層の膜厚］
単層の光吸収膜そのものを、熱レンズ形成層として作用させても良いが、光吸収と熱レンズ形成の機能を別々の材料に分担させて、各々選択された最適の材料を積層して使用することもできる。
【００７０】
光吸収層膜中の熱レンズ形成層の材料としては液体、液晶、および、固体の材料を用いることができる。特に、熱レンズ形成層が、非晶質の有機化合物、有機化合物液体、および液晶からなる群から選ばれる有機化合物からなると好適である。なお、熱レンズ形成層の材質が液晶および液体の場合、例えば、光吸収膜および／または伝熱層膜を自己形態保持性の材質で作成し、熱レンズ形成層の厚さに相当する空乏を設け、そこへ流動状態の熱レンズ形成層材料を注入することで、熱レンズ形成層を作成することができる。一方、熱レンズ形成層の材質が固体の場合は、熱レンズ形成層の片面または両面に光吸収膜を積層させて作成すれば良い。
【００７１】
熱レンズ形成層の材質は単一でなくとも良く、例えば、複数種類の固体の積層膜であっても良く、また、固体と液体を積層させたものであっても良い。
【００７２】
熱レンズ形成層の厚さは、用いる材料の種類にもよるが、数ナノメートルから１ｍｍの範囲の厚さであれば良く、数十ナノメートルから数百μｍの範囲であれば特に好適である。
【００７３】
前述のように、熱レンズ形成層と１または２枚の光吸収膜を積層してなる光吸収層膜の合計の厚さは、収束された前記制御光の共焦点距離の２倍を超えないことが好ましい。
【００７４】
光吸収層膜中の熱レンズ形成層の材料としては液体、液晶、および、固体の材料を用いることができるが、いずれの場合も屈折率の温度依存性が大きい材料が好ましい。
【００７５】
代表的な有機化合物液体および水の屈折率温度依存性の物性値は文献［D.Solimini:J.Appl.Phys.,vol.37,3314(1966)］に記載されている。波長６３３ｎｍの光に対する屈折率の温度変化［単位：１／Ｋ］は、水（0.8×10^{-4}）よりもメタノール（3.9×10^{-4}）などのアルコールが大きく、更に、シクロペンタン（5.7×10^{-4}）、ベンゼン（6.4×10^{-4}）、クロロホルム（5.8×10^{-4}）、二硫化炭素（7.7×10^{-4}）などの非水素結合性有機溶剤が大きい。
【００７６】

光吸収層膜中の熱レンズ形成層の材料として液晶を用いる場合、液晶としては、公知の任意のものを使用することができる。具体的には、種々のコレステロール誘導体、４’－ｎ－ブトキシベンジリデン－４－シアノアニリン、４’－ｎ－ヘキシルベンジリデン－４－シアノアニリンなどの４’－アルコキシベンジリデン－４－シアノアニリン類、４’－エトキシベンジリデン－４－ｎ－ブチルアニリン、４’－メトキシベンジリデンアミノアゾベンゼン、４－（４’－メトキシベンジリデン）アミノビフェニル、４－（４’－メトキシベンジリデン）アミノスチルベンなどの４’－アルコキシベンジリデンアニリン類、４’－シアノベンジリデン－４－ｎ－ブチトキシアニリン、４’－シアノベンジリデン－４－ｎ－ヘキシルオキシアニリンなどの４’－シアノベンジリデン－４－アルコキシアニリン類、４’－ｎ－ブトキシカルボニルオキシベンジリデン－４－メトキシアニリン、ｐ－カルボキシフェニル・ｎ－アミルカーボネイト、ｎ－ヘプチル・４－（４’－エトキシフェノキシカルボニル）フェニルカーボネイトなどの炭酸エステル類、４－ｎ－ブチル安息香酸・４’－エトキシフェニル、４－ｎ－ブチル安息香酸・４’－オクチルオキシフェニル、４－ｎ－ペンチル安息香酸・４’－ヘキシルオキシフェニルなどの４－アルキル安息香酸・４’－アルコキシフェニルエステル類、４，４’－ジ－ｎ－アミルオキシアゾキシベンゼン、４，４’－ジ－ｎ－ノニルオキシアゾキシベンゼンなどのアゾキシベンゼン誘導体、４－シアノ－４’－ｎ－オクチルビフェニル、４－シアノ－４’－ｎ－ドデシルビフェニルなどの４－シアノ－４’－アルキルビフェニル類などの液晶、および（２Ｓ，３Ｓ）－３－メチル－２－クロロペンタノイック酸・４’，４”－オクチルオキシビフェニル、４’－（２－メチルブチル）ビフェニル－４－カルボン酸・４－ヘキシルオキシフェニル、４’－オクチルビフェニル－４－カルボン酸・４－（２－メチルブチル）フェニルなどの強誘電性液晶を使用することができる。

【００７７】

光吸収層膜中の熱レンズ形成層の材料として固体の材料を用いる場合は、光散乱が小さく屈折率の温度依存性の大きな、非晶質の有機化合物が特に好適である。具体的には、前記マトリックス材料と同様に、種々の有機高分子材料の中から光学用樹脂として公知のものを選定して使用することができる。文献［技術情報協会編、「最新光学用樹脂の開発、特性と高精度部品の設計、成形技術」、技術情報協会(1993)、P.35］に記載されている光学用樹脂の屈折率の温度変化［単位：１／Ｋ］は、例えば、ポリ（メタクリル酸メチル）が$１．２×１０^{－４}$、ポリカーボネートが$１．４×１０^{－４}$、ポリスチレンが$１．５×１０^{－４}$である。これらの樹脂を光吸収層膜中の熱レンズ形成層の材料として好適に使用することができる。

【００７８】

前記有機溶剤の屈折率温度依存性は前記光学用樹脂の場合よりも大きいというメリットがある反面、制御光照射による温度上昇が有機溶剤の沸点に到達すると沸騰してしまうという問題がある（高沸点の溶剤を用いる場合は問題ない）。これに対して、揮発性不純物を徹底的に除去した光学用樹脂は、例えばポリカーボネートの場合、制御光照射による温度上昇が２５０℃を超えるような過酷な条件においても使用可能である。

【００７９】

［保温層膜］

保温層膜として気体を用いる場合は、空気の他、窒素、ヘリウム、ネオン、アルゴンなどの不活性ガスを好適に用いることができる。

【００８０】

保温層膜として液体を用いる場合は、熱伝導率が光吸収層膜と同等か光吸収層膜よりも小さい材質であって、かつ、制御光および信号光を透過し、光吸収層膜の材質を溶解または腐食しないものであれば、任意の液体を用いることができる。例えば、光吸収層膜がシアニン色素を含有したポリメタクリル酸メチルからなる場合、流動性パラフィンを用いることができる。

【００８１】

保温層膜として固体を用いる場合は、熱伝導率が光吸収層膜（光吸収膜および熱レンズ

形成層）と同等か光吸収層膜よりも小さい材質であって、かつ、制御光および信号光を透過し、光吸収層膜や伝熱層膜の材質と反応しないものであれば、任意の固体を用いることができる。例えば、光吸収層膜がシアニン色素を含有したポリメタクリル酸メチルからなる場合、色素を含まないポリメタクリル酸メチル［３００Ｋにおける熱伝導率０．１５Ｗ$m^{-1}K^{-1}$］を保温層膜として用いることができる。

【００８２】

［伝熱層膜の材料］

伝熱層膜としては、熱伝導率が光吸収層膜よりも大きい材質が好ましく、制御光および信号光を透過し、光吸収層膜や保温層膜の材質と反応しないものであれば、任意のものを用いることができる。熱伝導率が高く、かつ、可視光線の波長帯域における光吸収が小さい材質として、例えば、ダイアモンド［３００Ｋにおける熱伝導率９００$Wm^{-1}K^{-1}$］、サファイア［同４６$Wm^{-1}K^{-1}$］、石英単結晶［ｃ軸に平行方向で同１０．４$Wm^{-1}K^{-1}$］、石英ガラス［同１．３８$Wm^{-1}K^{-1}$］、硬質ガラス［同１．１０$Wm^{-1}K^{-1}$］などを伝熱層膜として好適に用いることができる。

【００８３】

［光透過層の材料］

本発明で用いられる熱レンズ形成素子は、図１１に示すように、前記制御光の収束手段としての屈折率分布型レンズが、光透過層を介して前記制御光の入射側に積層されて設けられていても良いが、光透過層の材質としては、固体の保温層膜および／または伝熱層膜の材質と同様のものを使用することができる。光透過層は、文字通り、前記制御光および信号光を効率良く透過させるだけでなく、屈折率分布型レンズを熱レンズ形成素子構成要素として接着するためのものである。いわゆる紫外線硬化型樹脂や電子線硬化型樹脂の内、前記制御光および信号光の波長帯域の光透過率の高いものを特に好適に用いることができる。

【００８４】

［熱レンズ形成素子の作成方法］

本発明で用いられる熱レンズ形成素子の作成方法は、熱レンズ形成素子の構成および使用する材料の種類に応じて任意に選定され、公知の方法を用いることができる。

【００８５】

例えば、熱レンズ形成素子中の光吸収膜に用いられる光吸収性の材料が、前述のような単結晶の場合、単結晶の切削・研磨加工によって、光吸収膜を作成することができる。

【００８６】

例えば、色素を含有したマトリックス材料からなる光吸収膜、光学用樹脂からなる熱レンズ形成層、および光学ガラスを伝熱層膜として組み合わせて用いた「伝熱層膜／光吸収膜／熱レンズ形成層／光吸収膜／伝熱層膜」という構成の熱レンズ形成素子を作成する場合、以下に列挙するような方法によって、まず、伝熱層膜上に光吸収膜を作成することができる。

【００８７】

色素およびマトリックス材料を溶解した溶液を、伝熱層膜として用いられるガラス板上に塗布法、ブレードコート法、ロールコート法、スピンコート法、ディッピング法、スプレー法などの塗工法で塗工するか、あるいは、平版、凸版、凹版、孔版、スクリーン、転写などの印刷法で印刷して光吸収膜を形成する方法を用いても良い。この場合、光吸収膜の形成にゾルゲル法による無機系マトリックス材料作成方法を利用することもできる。

【００８８】

電着法、電解重合法、ミセル電解法（特開昭６３－２４３２９８号公報）などの電気化学的成膜手法を用いることができる。

【００８９】

更に、水の上に形成させた単分子膜を移し取るラングミア・ブロジェット法を用いることができる。

【００９０】

原料モノマーの重合ないし重縮合反応を利用する方法として、例えば、モノマーが液体の場合、キャスティング法、リアクション・インジェクション・モールド法、プラズマ重合法、および、光重合法などが挙げられる。

【００９１】

昇華転写法、蒸着法、真空蒸着法、イオンビーム法、スパッタリング法、プラズマ重合法、ＣＶＤ法、有機分子線蒸着法、などの方法を用いることもできる。

【００９２】

２成分以上の有機系光学材料を溶液または分散液状態で各成分毎に設けた噴霧ノズルから高真空容器内に噴霧して基板上に堆積させ、加熱処理することを特徴とする複合型光学薄膜の製造方法（特許公報第２５９９５６９号）を利用することもできる。

【００９３】

以上のような固体の光吸収膜の作成方法は、例えば、固体の有機高分子材料からなる保温層膜を作成する場合にも、好適に使用することができる。

【００９４】

次いで、熱可塑性の光学用樹脂を用いて熱レンズ形成層を作成する場合、真空ホットプレス法（特開平４－９９６０９号公報）を用いて「伝熱層膜／光吸収膜／熱レンズ形成層／光吸収膜／伝熱層膜」という構成の熱レンズ形成素子を作成することができる。すなわち、熱可塑性光学用樹脂の粉末またはシートを、上記の方法で表面に光吸収膜を形成した２枚の伝熱層膜（ガラス板）で挟み、高真空下、加熱・プレスすることによって、上記構成の積層型薄膜素子を作成することができる。

【００９５】

［屈折率分布型レンズの材料と作成方法］

本発明で用いられる熱レンズ形成素子は、前記制御光の収束手段としての屈折率分布型レンズが、光透過層を介して前記制御光の入射側に積層されて設けられていても良いが、この屈折率分布型レンズの材料と作成方法としては、公知の、任意のものを使用することができる。

【００９６】

例えば、モノマーの浸透・拡散現象を利用して、屈折率分布型の屈折率分布型レンズを有機高分子系材質で作成することができる［M.Oikawa,K.Iga,T.Sanada: Jpn.J.Appl.Phys,20(1),L51-L54(1981)］。すなわち、モノマー交換技術によって、屈折率分布レンズを平坦な基板上にモノリシックに作ることができ、例えば、低屈折率プラスチックとしてのメタクリル酸メチル（ｎ＝１．４９４）を、３．６ｍｍφの円形ディスクのマスクのまわりから、高屈折率をもつポリイソフタル酸ジアクリル（ｎ＝１．５７０）の平坦なプラスチック基板中へ拡散させる。

【００９７】

また、無機イオンの拡散現象を利用し、屈折率分布型の屈折率分布型レンズを無機ガラス系材質で作成することができる［M.Oikawa,K.Iga: Appl.Opt.,21(6),1052-1056(1982)］。すなわち、ガラス基板にマスクを付けてからフォトリソグラフィの手法により直径百μｍ前後の円形窓を設け、溶融塩に浸けてイオン交換により屈折率分布を形成させるに当たり、数時間に渡って電界を印加してイオン交換を促進させることによって、例えば、直径０．９ｍｍ、焦点距離２ｍｍ、開口数ＮＡ＝０．２３のレンズを形成させることができる。

【００９８】

［光学セル］

色素溶液充填式熱レンズ形成素子で用いられる光学セルは、色素溶液を保持する機能、および色素溶液に実効的に形態を付与し、光吸収層膜兼熱レンズ形成層として作用させる機能を有し、更に、収束されて照射される信号光および制御光を受光して前記光応答性組成物へ前記信号光および前記制御光を伝搬させる機能、および前記光応答性組成物を透過した後、発散していく前記信号光を伝搬させて出射する機能を有するものである。

【００９９】

色素溶液充填式熱レンズ形成素子で用いられる光学セルの形態は外部形態と内部形態に大別される。

【0100】

光学セルの外部形態は、本発明の光制御式光路切替型光信号伝送装置の構成に応じて、板状、直方体状、円柱状、半円柱状、四角柱状、三角柱状、などの形状のものが用いられる。

【0101】

光学セルの内部形態とは、すなわち、色素溶液充填部の形態であり、色素溶液に、実効的に形態を付与するものである。本発明の光制御式光路切替型光信号伝送装置の構成に応じて、光学セルの内部形態は、具体的には、例えば、薄膜、厚膜、板状、直方体状、円柱状、半円柱状、四角柱状、三角柱状、凸レンズ状、凹レンズ状、などの中から適宜選択することができる。

【0102】

光学セルの構成および材質は、下記の要件を満たすものであれば任意のものを使用することができる。

【0103】

（１）上記のような外部形態および内部形態を、使用条件において精密に維持できること。

【0104】

（２）色素溶液に対して不活性であること。

【0105】

（３）色素溶液を構成する諸成分の放散・透過・浸透による組成変化を防止できること。

【0106】

（４）色素溶液が、酸素や水など使用環境に存在する気体あるいは液体と接触することによって劣化することを妨げることができること。

【0107】

光学セルの材質としては、具体的には、色素溶液の種類によらずソーダガラス、ホウケイ酸ガラスなどの種々の光学ガラス、石英ガラス、サファイアなどを好適に使用することができる。また、色素溶液の溶剤が水やアルコール系である場合、ポリ（メタクリル酸メチル）、ポリスチレン、ポリカーボネートなどのプラスチックを用いることもできる。

【0108】

なお、上記要件の内、色素溶液の組成変化や劣化を防止する機能は、熱レンズ形成素子としての設計寿命の範囲内に限り発揮できれば良い。

【0109】

本発明で用いられる他の光学要素、すなわち、集光レンズ、受光レンズ、波長選択透過フィルターなどを前記光学セルに組み込んだ一体構造の光学セルを用いることができる。

【0110】

［ビームウエスト直径の計算］

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法において熱レンズ効果を有効に利用するためには、焦点（集光点）近傍の光子密度が最も高い領域、すなわち「ビームウエスト」における前記信号光のビーム断面積が、ビームウエストにおける前記制御光のビーム断面積を超えないように前記信号光および前記制御光のビーム断面の形状および大きさをそれぞれ設定することが好ましい。

【0111】

以下、進行方向ビーム断面の電場の振幅分布、すなわち光束のエネルギー分布がガウス分布となっているガウスビームの場合について述べる。なお、以下の説明では、ビーム収束手段として集光レンズ（屈折率分布型レンズ）を用いる場合について説明するが、収束手段が凹面鏡や屈折率分散型レンズであっても同様である。

【0112】

ガウスビームを、図１などの集光レンズ３１などで、開き角２θで収束させたときの焦

点３０１近傍における光線束および波面３００の様子を図１４に示す。ここで、波長λのガウスビームの直径２ωが最小になる位置を「ビームウエスト」という。以下、ビームウエスト直径を$2\omega_0$で表すものとする。光の回折作用のため、$2\omega_0$はゼロにはならず、有限の値をもつ。なお、ビーム半径ωやω_0の定義は、ガウスビームのビーム中心部分のエネルギーを基準として、エネルギーが$1/e^2$（ｅは自然対数の底）になる位置をビーム中心から測ったときの距離であり、ビーム直径は２ωまたは$2\omega_0$で表される。いうまでもなく、ビームウエストの中心において、光子密度は最も高い。

【０１１３】

ガウスビームの場合、ビームウエストから充分に遠方でのビーム拡がり角θは波長λおよびビームウエスト径ω_0と、次の式〔４〕で関係付けられる。

【０１１４】

（数１）

$$\pi \cdot \theta \cdot \omega_0 \fallingdotseq \lambda \qquad \cdots〔4〕$$

ここで、πは円周率である。

【０１１５】

「ビームウエストから充分に遠方」という条件を満たす場合に限りこの式を用いて、集光レンズに入射するビーム半径ω、集光レンズの開口数および焦点距離から、集光レンズで集光されたビームウエスト径ω_0を計算することができる。

【０１１６】

更に一般的に、有効開口半径ａおよび開口数ＮＡの集光レンズで、ビーム半径ωの平行ガウスビーム（波長λ）を収束させた場合のビームウエスト直径$2\omega_0$は、次の式〔５〕で表すことができる。

【０１１７】

（数２）

$$2\omega_0 \fallingdotseq k \cdot \lambda / NA \qquad \cdots〔5〕$$

ここで、係数ｋは代数的に解くことができないため、レンズ結像面での光強度分布についての数値解析計算を行うことによって決定することができる。

【０１１８】

集光レンズに入射するビーム半径ωと集光レンズの有効開口半径ａの比率を変えて、数値解析計算を行うと、式〔５〕の係数ｋの値は以下のように求まる。

【０１１９】

（数３）

$a/\omega = 1$ のとき $k \fallingdotseq 0.92$

$a/\omega = 2$ のとき $k \fallingdotseq 1.3$

$a/\omega = 3$ のとき $k \fallingdotseq 1.9$

$a/\omega = 4$ のとき $k \fallingdotseq 3$

【０１２０】

すなわち、集光レンズの有効開口半径ａよりもビーム半径ωが小さければ小さい程、ビームウエスト径ω_0は大きくなる。

【０１２１】

例えば、集光レンズとして開口数０．２５、有効開口半径約５ｍｍのレンズを用い、波長７８０ｎｍの信号光を収束したとき、集光レンズに入射するビーム半径ωが５ｍｍであればａ／ωは約１で、ビームウエストの半径ω_0は１．４μｍ、ωが１．２５ｍｍであればａ／ωは約４でω_0は４．７μｍと計算される。同様にして波長６３３ｎｍの制御光を収束したとき、ビーム半径ωが５ｍｍであればａ／ωは約１で、ビームウエストの半径ω_0は１．２μｍ、ωが１．２５ｍｍであればａ／ωは約４でω_0は３．８μｍと計算される。

【０１２２】

この計算例から明らかなように、集光レンズの焦点近傍の光子密度が最も高い領域、すなわちビームウエストにおける光ビームの断面積を最小にするには、集光レンズに入射す

る光ビームの強度分布が平面波に近くなるまで、ビーム直径を拡大（ビームエキスパンド）すれば良い。また、集光レンズへ入射するビーム直径が同一の場合、光の波長が短い程、ビームウエスト径は小さくなることも判る。

【０１２３】

前述のように、本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法において熱レンズ効果を有効に利用するためには、ビームウエスト近傍の光子密度が最も高い領域における前記信号光のビーム断面積が、ビームウエストにおける前記制御光のビーム断面積を超えないように前記信号光および前記制御光のビーム断面の形状および大きさをそれぞれ設定することが好ましい。信号光および制御光ともにガウスビームを用いる場合であれば、以上の説明および計算式にしたがって、集光レンズなどの収束手段で収束する前の平行ビームの状態で、波長に応じて、信号光および制御光のビーム直径を、必要に応じてビームエキスパンドするなどして、調節することによって、ビームウエスト近傍の光子密度が最も高い領域における前記信号光のビーム断面積が、ビームウエストにおける前記制御光のビーム断面積を超えないようにすることができる。ビームエキスパンドの手段としては、公知のもの、例えば２枚の凸レンズからなるケプラー型の光学系を用いることができる。

【０１２４】

［共焦点距離Ｚｃの計算］

一般に、ガウスビームの場合、凸レンズなどの収束手段で収束された光束のビームウエスト近傍、すなわち、焦点を挟んで共焦点距離Ｚｃの区間においては、収束ビームはほぼ平行光と見なすことができ、共焦点距離Ｚｃは、円周率π、ビームウエスト半径ω_0および波長λを用いた式〔６〕で表すことができる。

【０１２５】

（数４）

$$Zc = \pi \omega_0^2 / \lambda \quad \cdots〔6〕$$

式〔６〕のω_0に式〔５〕を代入すると、式〔７〕が得られる。

【０１２６】

（数５）

$$Zc \fallingdotseq \pi (k / NA)^2 \lambda / 4 \quad \cdots〔7〕$$

【０１２７】

例えば、集光レンズとして開口数０．２５、有効開口半径約５ｍｍのレンズを用い、波長７８０ｎｍの信号光を収束したとき、集光レンズに入射するビーム半径ωが５ｍｍであればa/ωは約１で、ビームウエストの半径ω_0は１．４μｍ、共焦点距離Ｚｃは８．３μｍ、ωが１．２５ｍｍであればa/ωは約４でω_0は４．７μｍ、共焦点距離Ｚｃは８８μｍと計算される。同様にして波長６３３ｎｍの制御光を収束したとき、ビーム半径ωが５ｍｍであればa/ωは約１で、ビームウエストの半径ω_0は１．２μｍ、共焦点距離Ｚｃは６．７μｍ、ωが１．２５ｍｍであればa/ωは約４でω_0は３．８μｍ、共焦点距離Ｚｃは７１μｍと計算される。

【０１２８】

［集光レンズおよび受光レンズの開口数］

本発明の光制御式光路切替型光信号伝送装置および光信号光路切替方法においては、信号光および制御光を同軸で集光レンズによって収束させて熱レンズ形成素子中に焦点を結ぶように照射しているが、熱レンズ形成素子から通常よりも大きい開き角度で出射する光を受光レンズで受光して平行光にコリメートする場合、この受光レンズの開口数（以下、ＮＡと呼ぶ。）は、集光レンズのＮＡよりも大きくなるよう設定することが推奨される。更に受光レンズのＮＡは、集光レンズのＮＡの２倍以上が好ましい。ただし、集光レンズに入射するビーム半径ωよりも集光レンズの有効開口半径ａが大きい（すなわち$a/\omega > 1$）の場合は、集光レンズの実質的開口数は集光レンズの開口数よりも小さい。よって、受光レンズの開口数は、集光レンズ開口数ではなく集光レンズの実質的開口数よりも大きく、２倍以上に設定することが好ましい。受光レンズのＮＡを、集光レンズのＮＡの２倍

以上とすることによって、信号光のビーム直径が熱レンズ形成素子へ入射する際の２倍以上まで拡大されても、損失なしに受光することが可能となる。

【０１２９】

［光吸収層膜の最適膜厚］

光吸収層膜を構成する１または２枚の光吸収膜の厚さを変えず、熱レンズ形成層の厚さを変えて試料を作製し、光学濃度一定で膜厚の異なる複数の熱レンズ形成素子について実験した結果、上記のようにして計算される共焦点距離Ｚｃの２倍を光吸収層膜の膜厚の上限としたとき、熱レンズ効果の光応答速度が充分高速になることが判った。

【０１３０】

光吸収層膜の膜厚の下限については、熱レンズ効果が発揮できる限りにおいて、薄ければ薄いほど好ましい。

【０１３１】

［保温層膜の膜厚］

保温層膜の膜厚には、光応答の大きさおよび／または速度を最大にするような最適値（下限値および上限値）が存在する。その値は熱レンズ形成素子の構成、光吸収層膜の材質および厚さ、保温層膜の材質、伝熱層膜の材質および厚さなどに応じて、実験的に決定することができる。例えば、伝熱層膜として通常のホウケイ酸ガラス、保温層膜および熱レンズ形成層の材質としてポリカーボネート、光吸収膜としてプラチナフタロシアニンの蒸着膜を用い、ガラス（伝熱層膜、膜厚１５０μｍ）／ポリカーボネート樹脂層（保温層）／プラチナフタロシアニン蒸着膜（光吸収膜、膜厚０．２μｍ）／ポリカーボネート樹脂層（熱レンズ形成層、膜厚２０μｍ）／プラチナフタロシアニン蒸着膜（光吸収膜、膜厚０．２μｍ）／ポリカーボネート樹脂層（保温層）／ガラス（伝熱層膜、膜厚１５０μｍ）という構成の熱レンズ形成素子を作成した場合、保温層膜の膜厚は好ましくは５ｎｍから５μｍであり、更に好ましくは５０ｎｍから５００ｎｍである。

【０１３２】

［伝熱層膜の膜厚］

伝熱層膜の膜厚にも、光応答の大きさおよび／または速度を最大にするような最適値（この場合は下限値）が存在する。その値は熱レンズ形成素子の構成、光吸収層膜の材質および厚さ、保温層の材質および厚さ、伝熱層膜の材質などに応じて、実験的に決定することができる。例えば、伝熱層膜として通常のホウケイ酸ガラス、保温層膜および熱レンズ形成層の材質としてポリカーボネート、光吸収膜としてプラチナフタロシアニンの蒸着膜を用い、ガラス（伝熱層膜、膜厚１５０μｍ）／ポリカーボネート樹脂層（保温層）／プラチナフタロシアニン蒸着膜（光吸収膜、膜厚０．２μｍ）／ポリカーボネート樹脂層（熱レンズ形成層、膜厚２０μｍ）／プラチナフタロシアニン蒸着膜（光吸収膜、膜厚０．２μｍ）／ポリカーボネート樹脂層（保温層）／ガラス（伝熱層膜、膜厚１５０μｍ）という構成の熱レンズ形成素子を作成した場合、伝熱層膜の厚さの下限は、好ましくは１０μｍ、更に好ましくは１００μｍである。なお、伝熱層膜の膜厚の上限については光応答の大きさおよび／または速度からの制約はないが、用いられる集光レンズおよび受光レンズの方式、焦点距離および作動距離（ワーキングディスタンス）と整合させて設計する必要がある。

【実施例】

【０１３３】

以下、本発明の実施形態について、実施例を参照しながら詳細に説明する。

【０１３４】

［実施例１］

図１ａには、実施例１の光制御式光路切替型光信号伝送装置の概略構成が示されている。図１ａの光制御式光路切替型光信号伝送装置は、１つの信号光光源２０と、信号光１２０とは波長が異なる、３つの互いに波長の異なる制御光光源２１，２２，２３と、信号光１２０と３つの制御光１２１，１２２，１２３の全ての光軸を揃えて同軸で同方向に伝搬させるためのダイクロイックミラー５１，５２，５３と、信号光１２０と３つの制御光１

２１，１２２，１２３を合わせて、光ファイバー１００へ入射させるための集光レンズ１０と、信号光１２０および３つの制御光１２１，１２２，１２３を合わせて伝送する光ファイバー１００と、光ファイバー１００から出射する信号光１２０および３つの制御光１２１，１２２，１２３を実質的に平行ビームに戻すためのコリメートレンズ３０と、「熱レンズ入射光集光レンズ（３１，３２，３３）、熱レンズ形成素子（１，２，３）、熱レンズ出射光受光レンズ（４１，４２，４３）、波長選択透過フィルター（８１，８２，８３）および穴付ミラー（６１，６２，６３）」からなる光路切替機構９１，９２，９３を３段直列に連結した場合を例示したものである。光路切替機構９１および９２から出射する直進信号光１１１および１１２は、空間的に結合されて、各々後段の光路切替機構９２および９３の熱レンズ入射光集光レンズ３２および３３へ入射し、３段目の光路切替機構９３から出射する直進信号光１１３は直進出射信号光の集光レンズ４０１によって集光され、直進出射信号光の光ファイバー１０１へ入射する。また、光路切替機構９１，９２，９３から光路が切替られて出射する信号光２１１，２１２，２１３は、各々光路切替後の出射信号光集光レンズ７１，７２，７３によって集光され、光路切替後の出射信号光光ファイバー１１，１２，１３へ入射する。光ファイバー１１，１２，１３，１００，１０１として、通常の単一モード石英光ファイバー（長さ１０ないし１００ｍ）を用いた。単一モード石英光ファイバーの代わりにマルチモード石英光ファイバー、ＳＩ型プラスチック光ファイバー、ＧＩ型プラスチック光ファイバーなどを、制御光および信号光の透過率／伝送距離特性に応じて選択し、使用することができる。

【０１３５】

光路切替機構の連結数は、互いに波長の異なる信号光光源の数に対応する。ただし、光路切替機構１段当たりの信号光の透過率、光制御式光路切替型光信号伝送装置に入射する信号光の初期強度、および、最終的に必要な信号光強度から連結可能な段数が計算される。例えば、光路切替機構１段当たりの透過率が８５％（信号強度として０．７ｄＢ減衰）であれば、４段直列連結の場合の総合透過率は５２．２％（同２．８ｄＢ減衰）となる。

【０１３６】

以下、図１ａに示す３段直列構成を例にして、詳細に説明する。なお、図１ａにおける集光レンズ３１および熱レンズ形成素子１の部分を抜き出した部分図を図７および図８に、更に受光レンズ４１および穴付ミラー６１などを加えた部分図を図９および図１０に示す。また、光路切替機構を３個以上設けた装置の構成図が複雑になることを避けるため、図１ａに示すように光路切替機構９１，９２，９３を空間結合型で連結させる場合、空間結合型の光路切替機構の概略構成図（図２ａの左図）を一部記号化して、図２ａの右図のように表示することとする。すなわち、例えば、図１ａの光制御式光路切替型光信号伝送装置は図１ｂのように一部記号化された概略構成図で表示される。図１ａと図１ｂは表記方法が異なる以外は同一内容の概略構成図であることから、以下、図１ａと図１ｂを区別する必要がない場合、単に「図１」と呼ぶこととする。

【０１３７】

また、２つ以上の光路切替機構を光ファイバー結合型で連結させることもできるが、この場合、光ファイバー結合型の光路切替機構の概略構成図を省略して、図３のように表示することとする。

【０１３８】

なお、図１ａないし図３、および図７ないし図１０において、熱レンズ形成素子１を「伝熱層膜５０１／光吸収層膜５０３／伝熱層膜５０２」という３層構造として図示するが、これに限定されない。

【０１３９】

本実施例では、熱レンズ形成素子１，２および３として、各々前述の色素〔１〕、〔２〕および〔３〕の溶液を充填した色素溶液充填式熱レンズ形成素子８００（図２１）を用いた。前記色素を溶解させる溶剤としては徹底的に脱水および脱気したo-ジクロロベンゼンを用いた。光学セル８０９は熱レンズ形成素子１，２および３について同一形状のものを用い、その色素溶液充填部８０８の厚さ、すなわち、入射・出射面ガラス８０１と８０

２の内部における間隔は例えば２００μｍとした。光学セル８０９の入射・出射面ガラス８０１と８０２の外面にはＡＲコートを施した。また、光学セル８０９の導入口８０７は、色素溶液の充填および脱気処理を行った後、溶融・封印した。色素溶液の濃度は０．２ないし２重量％の間で調節し、色素〔１〕、〔２〕および〔３〕について、各々５３２ｎｍ、６７０ｎｍおよび８００ｎｍの透過率が０．０ないし０．２％、信号光８５０ｎｍの透過率が８５ないし９９％になるよう調整した。

【０１４０】

本実施例では、光ファイバー１００からの入射信号光１１０をコリメートレンズ３０でビーム半径５．０ｍｍのほぼ平行光線になるようにしている。

【０１４１】

本実施例では、信号光１２０の光源２０として、例えば、２．５ＧＨｚで変調可能な発振波長８５０ｎｍの面発光型半導体レーザーを用いているが、発振波長１３５０ｎｍ、１５５０ｎｍの超高速変調可能な半導体レーザー光を用いても良い。また、これら複数の波長の信号光を同時に用いても良い。本実施例では、熱レンズ形成素子１，２および３に各々熱レンズを形成させるための制御光１２１，１２２および１２３を照射する制御光光源２１，２２および２３として、各々、発振波長５３２ｎｍの半導体励起Ｎｄ：ＹＡＧレーザーの２次高調波、６７０ｎｍおよび８００ｎｍの半導体レーザーを用い、制御光の断続によって信号光光路の切替を行っている。制御光１２１，１２２および１２３は、いずれもビーム半径４．５ｍｍの平行光線になるように、ビーム成形して用いている。制御光光源のレーザーパワーは、集光レンズ３１，３２または３３のいずれの手前においても２ないし１０ｍＷとしている。

【０１４２】

制御光１２１，１２２および１２３、および、信号光１１０，１１１および１１２を共通の集光レンズ３１，３２および３３で各々収束させて熱レンズ形成素子１，２および３へそれぞれ照射している。制御光および信号光の各々のビームウエストが、熱レンズ形成素子中において互いに重なり合うように、光ファイバー１００へ入射させる前に、信号光と制御光をダイクロイックミラー５１，５２および５３を用いて同一光軸、かつ、信号光と制御光が互いに平行になるように調整している。このようにすることによって、制御光ビームウエスト位置における光吸収によって形成された熱レンズ効果を、効率良く信号光の進行方向変更に利用することが可能になる。

【０１４３】

前記信号光および３つの制御光はいずれも、ビーム断面の光強度分布がガウス分布であるものを用いた。このようなレーザー光をレンズで集光すると、ビームウエスト（集光点；焦点）での光強度分布は、ガウス分布となる。光吸収膜で吸収される波長帯域のレーザー光を制御光として、前記光吸収膜を含む熱レンズ形成素子に集光レンズを通して照射し、熱レンズ形成層を含む光吸収層膜中で収束させると、光吸収膜がレーザー光を吸収して熱レンズ形成層の温度が上昇し、その結果、屈折率が下がる。上記のようにガウス分布となった光を照射すると、光強度の強いガウス分布の中心部分が収束され、照射されたところが「光吸収の中心」となり、その部分の温度が最も高く、かつ、屈折率が一番小さくなる。光吸収の中心部分から外周へ向けての光吸収が熱に変わり、更に周囲に伝搬される熱により熱レンズ形成層を含む光吸収層膜の屈折率が光吸収中心から外部へ向けて球状に変化して光吸収中心の屈折率が低く外部へ向けて屈折率が高くなる分布を生じ、これが凹レンズのように機能する。すなわち、光は、屈折率の大きいところよりも小さいところで、速度が大きく、したがって、光強度の強いガウス分布の中心部分が照射されたところを光が通過するときの光速は、光強度の弱いガウス分布の周辺部分が照射されたところを光が通過するときの光速よりも大きい。よって光は、光強度の弱いガウス分布の周辺部分が照射された方向に曲がる。これは、局部的には、大気中での凹レンズと同じ動作である。実際には、制御光は集光レンズ３１などによって集光されて熱レンズ形成層を含む光吸収層膜中に照射され、光吸収が収束光の進行方向に多重に起こり、多重に形成された熱レンズによって、進行する制御光自身の光束も変形されるため、観測される熱レンズ効果は、後

述のように単一の凹レンズによるものとは異なる。
【０１４４】
本実施例では、熱レンズ形成素子１，２および３を通過した信号光を受光レンズ４１，４２および４３でほぼ平行光にコリメートしている。この受光レンズの開口数（以下、「ＮＡ」と呼ぶ。）は、集光レンズのＮＡよりも大きくなるよう設定している。本実施例では、集光レンズのＮＡは０．２５、受光レンズのＮＡは０．５５を用いている。受光レンズのＮＡは、集光レンズのＮＡの２倍以上が好ましい。この関係が満足されれば、集光レンズとコリメートレンズのＮＡの組み合わせは、この実施例に限らない。受光レンズのＮＡを、集光レンズのＮＡの２倍以上とすることによって、信号光のビーム直径が熱レンズ形成素子へ入射する際の２倍以上まで拡大されても、損失なしに受光することが可能となる。なお、本実施例では集光レンズと受光レンズの焦点距離は同一とし、集光レンズの有効直径は約１０ｍｍのものを用いた。
【０１４５】
受光レンズ４１，４２および４３でコリメートした信号光を穴付ミラー６１，６２および６３に入射させている。後に詳細に説明するように、この穴付ミラーを設けることで信号光の光路を切り替えることが可能となる。
【０１４６】
光吸収層膜の吸収帯域にある波長の制御光と透過帯域の波長である信号光とを、図７（ａ）に示すように熱レンズ形成素子１の光吸収層膜の入射面に近い位置５において焦点を結ぶように同時に照射すると、図８（ａ）に示すように制御光により入射面に近い位置に形成された熱レンズ５０により、信号光は断面がリング状に拡がるように拡散された出射光２０１として通常の出射光２００よりも大きい開き角度で出射する。一方、図７（ｂ）に示すように熱レンズ形成素子の光吸収層膜の出射面に近い位置６において焦点を結ぶように同時に照射すると、図８（ｂ）に示すように制御光により出射面に近い位置に形成された熱レンズ６０により、信号光は収束された出射光１１９として出射する。図７（ａ）および図７（ｂ）のいずれの場合も、制御光を照射しないと、図８（ａ）および図８（ｂ）に点線で示すように信号光は熱レンズ５０または６０の影響を受けることなく、信号光のみが通常の開き角度の出射光２００として出射する。
【０１４７】
このような熱レンズ効果を調べるため、熱レンズ効果の有無と集光点位置の相違に対応した信号光ビーム断面における光強度分布の相違の測定を行った。すなわち、図１または図９に概要を示す装置において、受光レンズ４１の開口数０．５５、集光レンズ３１の開口数０．２５とし、穴付ミラー６１の代わりに図１３に概要を示すような光強度分布測定器７００を設置し、熱レンズ形成素子１を透過した信号光ビームの全てを受光レンズ４１で受光し、平行光線として前記光強度分布測定器の受光部７０１（有効直径２０ｍｍ）へ入射させ、信号光ビーム断面の光強度分布を測定した。測定結果を図１８、図１９、および、図２０に示す。ここで、光強度分布測定器は、図１３に示すように、受光部７０１（有効直径２０ｍｍ）に対して幅１ｍｍの第一のスリット７０２を設け、第一のスリットの長さ方向、すなわち図１３において点７１０から点７２０の向きに、幅２５μｍの第二のスリット７０３を一定速度で移動させて、２枚のスリットが作る１ｍｍ×２５μｍの長方形の窓を通過した光の強度を、前記窓の移動位置に対応させて測定する装置である。前記窓の移動位置に対応させて光強度を測定するには、例えば、第二のスリット７０３の移動速度に同期させたストレージオシロスコープ上に、前記窓を通過した光を受光した検出器の出力を記録すれば良い。図１８～図２０は、以上のようにして、ストレージオシロスコープ上に記録された信号光の光ビーム断面についての光強度分布を示すものであり、横軸（光ビーム断面内の位置）は受光部７０１の中心を０として、図１３の点７１０を負方向、点７２０を正方向と座標を定めて表した位置に対応し、縦軸は光強度を表す。
【０１４８】
図１８は、図９（ａ）の場合に対応し、熱レンズ形成素子１に制御光が入射せず、信号光のみが入射した場合の前記信号光ビーム断面の光強度分布である。この場合の光強度分

布は、中心部分の強度が強く、周辺にいくにしたがって強度が弱まる分布（おおむね「ガウス分布」）である。したがって、この場合に充分な大きさの穴１６１を有する穴付ミラー６１が図９（ａ）のように設置されていると、信号光ビーム１１１の全てが穴付ミラーの穴１６１を通過することができる。ここで、平行光として集光レンズ３１（焦点距離f_1）へ入射する信号光のビーム直径をd_1、受光レンズ４１（焦点距離f_2）によって平行光とされた信号光ビーム１１１のビーム直径をd_2とすると、

（数６）

$$f_1 : f_2 = d_1 : d_2 \quad \cdots〔8〕$$

であるから、d_2は次の式によって求めることができる。

【０１４９】

（数７）

$$d_2 = (f_2 / f_1) \times d_1 \quad \cdots〔9〕$$

【０１５０】

穴付ミラー６１は、本実施例１では、信号光の光軸と４５度の角度をもって設置されている。また、穴１６１を通過する信号光の断面は円形である。したがって、穴１６１の形状は短径D_1、長径D_2の楕円である必要があり、D_1とD_2は次の式〔１０〕の関係にある。

【０１５１】

（数８）

$$D_2 = D_1 \times \sqrt{2} \quad \cdots〔10〕$$

【０１５２】

ここで、穴付ミラー６１の楕円形穴１６１の短径D_1は、式〔９〕から求められる信号光ビーム１１１のビーム直径d_2よりも大きければ良い。ただし、D_1が大きすぎると制御光の照射によってリング状に拡大された信号光の一部も通過してしまう。すなわち、D_1の最適値はd_2の１．０１倍ないし１．２倍であり、より好ましくは１．０２倍ないし１．１倍である。

【０１５３】

本実施例１において、集光レンズ３１の焦点距離f_1と受光レンズ４１の焦点距離f_2は同一とした。したがって、集光レンズ３１に入射する信号光１１０のビーム直径d_1と受光レンズによって平行光とされた信号光１１１のビーム直径d_2は同一であり、前述のように１０ｍｍである。したがって、本実施例１における穴付ミラー６１の楕円形穴１６１の短径D_1は１０．１ｍｍないし１２ｍｍが好ましく、より好ましくは１０．２ｍｍないし１１ｍｍであり、実際には１０．５ｍｍとした。D_2は式〔７〕から１４．８ｍｍである。また、ミラーのサイズは、直径３０ｍｍのビームを４５度反射可能な大きさ（５０ｍｍ角）のものを用いた。

【０１５４】

図１９は、焦点（集光点）を熱レンズ形成素子１の集光レンズ３１に近い位置５（光の入射側）に設定し、制御光を照射したときの信号光ビーム断面の光強度分布である。この場合の光強度分布は、中心部分の光強度が弱く、周辺でリング状に光強度が増大する分布になっている。信号光ビーム断面の中心部の光強度は、制御光強度および熱レンズ形成素子１と焦点の位置関係に依存して減少し、制御光強度が増すにしたがって、ゼロに近づいていく。また、信号光強度の極大位置は、元のビーム直径よりも大きな値（直径約１５ｍｍ）であった。

【０１５５】

図２０に対応する熱レンズ効果の利用については、実施例２に記載する。

【０１５６】

以上、まとめると、図８（ａ）の光学配置において、制御光照射の有無に対応して、熱レンズ形成素子を通過した信号光のビーム断面の光強度分布が図１９のリング状分布（制御光照射の場合）と図１８のガウス分布（制御光非照射の場合）の間で切り替えられ、これを、信号光ビーム断面の光強度分布の形状に適合した穴付ミラーによって、それぞれ別

個に取り出すことによって、信号光の光路の切替が可能となる。

【０１５７】

穴付ミラー６１は、本実施例１では、信号光の光軸と４５度の角度をもって設置されている。穴付ミラー６１のミラー面は、ガラス面上に誘電体多層膜をスパッタリング法で作成し、信号光の波長で反射率が極大になるよう調整したものを用いた。穴付ミラー６１の穴１６１の部分は、ガラスに楕円状の穴を、４５度傾けて開けて作成した。穴を開ける替わりに、楕円状に反射膜を付けなくても良いが、ガラス面には反射が数％あって信号光の減衰かつクロストークが起こるので、穴を開ける方が好ましい。穴の内面は光散乱などによる迷光を防ぐため、平滑で、無反射処理されていることことが好ましい。また、反射膜は、誘電体多層膜に限らず、用いる制御光と信号光に反射がある材料であれば良く、金、銀等でも良い。

【０１５８】

光路切替によって、図１に示すように、信号光本来の進行方向から９０度方向変換して取り出した信号光（スイッチ信号光）２１１，２１２および２１３は、集光レンズ７１，７２および７３で集光して光ファイバー１１，１２および１３に入射させている。

【０１５９】

制御光の光源２１，２２および２３の全てが消灯している場合、信号光は熱レンズ効果を受けず、信号光１１１，１１２、次いで１１３として出射する。出射信号光１１３を集光レンズ４０１によって集光して光ファイバー１０１に入射させている。

【０１６０】

なお、光ファイバー１１，１２，１３、または、１０１の代わりに光検出器等に入射させて、情報を電気信号に変換して取り出しても良い。

【０１６１】

ここで、熱レンズ形成素子１，２および３における制御光の透過率が０％でない限り、透過率に相当する分の制御光も熱レンズ形成素子１，２および３を透過し、出射して来る。この制御光が後段の熱レンズ形成素子等に入射して誤動作ないしクロストークを起こすことを避けるため、熱レンズ形成素子１，２および３における各々の制御光の透過率を０％に限りなく近づける必要がある。更に、熱レンズ形成素子１，２および３の後ろまたは集光レンズ４１，４２，および４３の後ろに波長選択透過フィルター８１，８２，８３を、設けることが好ましい。これらの波長選択透過フィルターとしては、個々の制御光の波長帯域の光を完全に遮断し、一方、信号光および後段の光路切替機構のための制御光の波長帯域の光を効率良く透過することのできるような波長選択透過フィルターであれば、公知の任意のものを使用することができる。例えば、色素で着色したプラスチックやガラス、表面に誘電体多層膜を設けたガラスなどを用いることができる。このような波長選択透過フィルター用材料からなる薄膜を集光レンズ４１，４２，および４３の表面に塗工法、スパッタリング法などの手法で形成し、前記波長選択透過フィルターとしての機能を発揮させても良い。

【０１６２】

本実施例の光制御式光路切替型光信号伝送装置は、「集光レンズ、熱レンズ形成素子、受光レンズ、および穴付ミラー」からなる光路切替機構を３段直列に連結したものである。したがって、制御光を全て消灯している場合は信号光は直進して光ファイバー１０１へ入射するのに対し、制御光２１を点灯した場合は信号光２１１が光ファイバー１１へ、制御光２１を消灯し制御光２２を点灯した場合は信号光２１２が光ファイバー１２へ、更に、制御光２１および２２を消灯し制御光２３を点灯した場合は信号光２１３が光ファイバー１３へ、光路が切り替えられて出射する。複数の制御光を同時に点灯するケースについては後の実施例で説明する。

【０１６３】

本実施例１の光制御式光路切替型光信号伝送装置において、第１段目の光路切替機構の光応答速度を測定するため、信号光を連続光とし、一方、制御光１２１を周波数数Ｈｚから１００ｋＨｚで、デューティ比１：１の矩形波断続光線として照射し、光路切替された

信号光の強度振幅の大小を比較した。

【０１６４】

図１に示す制御光光源２１からの制御光１２１を光検出器に導いてオシロスコープ上で測定した制御光の波形１２１０および制御光１２１の明滅に対応して光路切替された信号光２１１を光検出器に導いてオシロスコープ上で測定した信号光の波形１２２０を図１５および図１６に示す。なお、図１６の縦軸は図１５の場合の３倍に拡大されている。また、制御光１２１を断続する矩形波の周波数を２００Ｈｚないし１００ｋＨｚに設定し、そのときの信号光の断続に対応する信号光の波形１２２０の振幅Ｌを測定した結果を図１７に示す。

【０１６５】

図１５において制御光１２１（図１）を断続する矩形波の周波数５００Ｈｚであり、このときの信号光の断続に対応する信号光の波形１２２０の振幅Ｌを基準の１とすると、制御光１２１（図１）を断続する矩形波の周波数範囲０．２から２ｋＨｚにおいて、振幅Ｌは、ほぼ１であった。すなわち、５００マイクロ秒で完全な光路切替が可能であることが確認された。これは、電気ヒーターを用いた熱光学効果を用いた光スイッチ（応答速度はミリ秒オーダー）に比べ、２倍以上の高速応答である。

【０１６６】

更に周波数を高めた場合の例として、周波数２０ｋＨｚにおける信号光の波形１２２０を図１６に示す。図１６から判るように熱レンズ効果による光路切替が完了しない内に制御光を消灯すると、信号光の波形はのこぎりの刃状になり、振幅Ｌは小さくなっていく。すなわち、熱レンズ効果の応答速度を超えると光路の切替は不完全になり、信号光の一部は光路切替されずに直進する。

【０１６７】

以上のような第１段目の光路切替機構において行った光応答速度測定のと同様の測定を、第２段目および第３段目の光路切替機構において、各々信号光１２２および１２３を断続させて実施したところ、第１段目と同等の高速応答を示した。

【０１６８】

本実施例１の光制御式光路切替型光信号伝送装置の耐久性を測定するため、信号光を連続光とし、一方、制御光１２１，１２２および１２３を各々、周波数数１ｋＨｚで、デューティ比１：１の矩形波断続光線として照射し、光路切替された信号光の強度振幅の時間を比較した。その結果、各々連続１万時間経過しても、信号光の強度振幅は減衰しなかった。

【０１６９】

本実施例１の光制御式光路切替型光信号伝送装置の偏波依存性を検証するため、信号光および制御光に１枚の偏光素子を挿入し、偏光角を種々変化させる実験を行ったが、偏波依存性は全く認められなかった。

【０１７０】

本実施例１の光制御式光路切替型光信号伝送装置の出射直進光と光路切替光とのクロストーク特性を調べるため、制御光全て消灯、制御光光源２１のみ点灯、制御光光源２２のみ点灯、および、制御光光源２３のみ点灯の各々の場合について、光ファイバー１０１，１１，１２，１３からの出射光強度を比較したところ、目的とする出射光強度に対するモレ光（クロストーク）強度は２０００ないし８０００：１（－３３ないし３９ｄＢ）と微弱であった。

【０１７１】

［実施例２］

信号光ビーム断面における光強度分布の一例を表す図２０は、図８（ｂ）および図１０（ｂ）に示すような光学配置の場合に対応し、焦点（集光点）を図７（ｂ）に示す熱レンズ形成素子１の受光レンズ４１に近い位置６（光の出射側）に設定し、制御光を照射したときの信号光ビーム断面の光強度分布である。この場合は、中心部分の光強度が、制御光を照射しない場合の中心部分の光強度（図１８）より強くなっている。この場合、信号光

ビーム断面の中心部の光強度は、制御光強度および熱レンズ形成素子１と焦点６との位置関係に依存するが、制御光非照射時の数倍にも達する。

【０１７２】

したがって、この場合に穴付ミラー６１が設置されていると、信号光ビームの大部分が穴付ミラーの穴１６１を通過する。ここで、穴付ミラー６１（および６２，６３）の穴１６１の大きさが最適化（本実施例２の場合、直径２ｍｍ）されていると、穴付ミラー６１によって反射される信号光を事実上ゼロにすることができる。しかしながら、穴付ミラー６１の穴１６１の大きさを最適化しても、制御光を照射しない場合（図９（ａ）、図８）において、図１０（ａ）に示すような信号光の中心部分が穴１６１を漏れ信号光１１８として通過してしまうことは防げない。すなわち、本実施例２の光制御式光路切替型光信号伝送装置においては、信号光ビーム断面の光強度分布がガウス分布ないしガウス分布に近い場合、図１０（ａ）における信号光２１１に対して、必ず、ある程度の漏れ信号光１１８（クロストーク）が発生する。

【０１７３】

しかるに、熱レンズ形成素子へ入射する信号光ビーム断面の光強度分布を変更することによって、このような漏れ信号光を事実上ゼロにすることができる。すなわち、図１および図２ｂに示すように、光ファイバー１００から出射した信号光１１０をコリメートレンズ３０を用いて整形した後、円錐プリズム型レンズなどからなるビーム断面リング化レンズ群３２１によって、信号光ビーム断面の光強度分布を図１９に相当するようなリング状の分布にすることが容易にできる。このような断面光強度分布の信号光１１０を集光レンズ３１にて焦点位置６（図１０（ａ））を通過するように収束して熱レンズ形成素子１を透過させた後、受光レンズ４１で平行光線に戻すと、その光ビーム断面の光強度分布は図１９に相当するように周辺部分で強く、中心部分が事実上ゼロの「リング状」となるため、穴付ミラー６１を設置した場合、その穴１６１を通過する信号光のモレを事実上、なくすることができる。信号光ビーム断面の光強度分布がこのように「リング状」であっても、図９（ｂ）のように制御光を照射して熱レンズ６０を過渡的に形成させた場合には、信号光ビーム断面の光強度分布は鋭いビーム状の収束直進信号光１１９として穴付ミラー６１の穴１６１を通過していく。

【０１７４】

図１０に例示するような光学配置において、制御光および信号光の焦点が熱レンズ形成素子の出射側に近い位置６になるよう調整し、更に信号光ビーム断面の光強度分布をリング状にすることによって、制御光非照射のとき、信号光本来の進行方向から９０度、光路を切り替えて信号光を出射させること、また、制御光照射時に信号光を直進させることができる。

【０１７５】

本実施例２の光制御式光路切替型光信号伝送装置は、実施例１（図１）における光路切替機構９１，９２，９３を図２ｂに例示されるような光路切替機構１９１に全て置き換えたものであって、信号光および制御光の焦点（集光点）を熱レンズ形成素子１の受光レンズ４１に近い位置６（光の出射側）に設定し、穴付ミラー６１の穴１６１を実施例１の場合よりも小さく、直径２ｍｍとしたものである。この場合、信号光および制御光の焦点（集光点）を熱レンズ形成素子１の受光レンズ４１に近い位置６（光の出射側）に設定するため、熱レンズ形成素子の光吸収層膜における制御光の透過率は、１ないし５％であることが好ましい。光路切替機構１９１に入射する信号光１１０のビーム断面光強度分布がガウス分布ないしガウス分布に類似であって、リング状でない場合、円錐プリズム型レンズなどからなるビーム断面リング化レンズ群３２１によって、信号光ビーム断面の光強度分布をリング状にすることが好ましい。また、信号光と制御光が同時に照射された場合、制御光の光吸収によって形成された熱レンズ６０を出射する収束直進信号光１１９は、ビーム径が小さいため、後段で集光する場合、前述のようにビームウエストが大きめになってしまう。これを避けるため、収束直進信号光１１９をビームエキスパンダー３３１によって、入射信号光１１０と同等の半径５ｍｍまで拡大させた信号光１１１として出射させる

ことが好ましい。

【０１７６】

本実施例２の光制御式光路切替型光信号伝送装置の制御光１２１，１２２，１２３の点灯の組み合わせと光路切替の関係は次の通りである。少なくとも制御光１２１を消灯した場合、信号光１１０は穴付ミラー６１の反射面によって反射され、光路切替信号光２１１として出射し、集光レンズ７１によって集光され、光ファイバー１１へ入射する。制御光１２１を点灯した場合、信号光１１０は収束直進信号光１１９として穴付ミラー６１の穴１６１を通過した後、ビームエキスパンダー３３１によって入射信号光１１０と同じビーム径まで拡大されて第２段目の光路切替機構１９２（図４）に入射する。制御光１２１が点灯し、制御光１２２が消灯されている場合、信号光１１１は光路切替光２１２として出射し、光ファイバー１２に入射する。制御光１２１と１２２が同時に点灯している場合、信号光は直進し、信号光１１２として第３段目の光路切替機構１９３（図４）に入射し、制御光１２１と１２２が同時に点灯し、かつ、制御光１２３が消灯している場合、光路切替光２１３として光ファイバー１３へ入射する。制御光１２１，１２２，１２３が全て点灯している場合、信号光１１０は最終的に直進信号光１１３として出射し、集光レンズ４０１によって集光され、光ファイバー１０１へ入射する。

【０１７７】

本実施例２の光制御式光路切替型光信号伝送装置の光応答速度を測定するため、信号光を連続光とし、一方、制御光１２１を周波数数Ｈｚから１００ｋＨｚで、デューティ比１：１の矩形波断続光線として照射し、光路切替された信号光の強度振幅の大小を比較した。その結果、１Ｈｚのときの信号光の強度振幅を基準として、２ｋＨｚまで、強度振幅は変化せず、更に周波数を高めた場合、強度振幅は徐々に減衰し、１０ｋＨｚのとき半減した。すなわち、５００マイクロ秒で完全な光路切替が可能であることが確認された。これは、電気ヒーターを用いた熱光学効果を用いた光スイッチに比べ、２倍以上の高速応答である。制御光１２２および１２３を同様に断続しても、１２１を断続した場合と同等の応答速度が観測された。

【０１７８】

本実施例２の光制御式光路切替型光信号伝送装置の耐久性を測定するため、信号光を連続光とし、一方、制御光１２１，１２２，１２３を各々周波数１ｋＨｚで、デューティ比１：１の矩形波断続光線として照射し、光路切替された信号光の強度振幅の時間を比較した。その結果、各々連続１万時間経過しても、信号光の強度振幅は減衰しなかった。

【０１７９】

本実施例２の光制御式光路切替型光信号伝送装置の出射直進光と光路切替光とのクロストーク特性を調べるため、制御光全て消灯、制御光１２１のみ点灯、制御光１２１および１２２のみ点灯、および、制御光１２１，１２２，１２３全て点灯の各々の場合について、光ファイバー１０１，１１，１２，１３からの出射光強度を比較したところ、目的とする出射光強度に対するモレ光（クロストーク）強度は１０００ないし２０００：１（－３０ないし３３ｄＢ）と微弱であった。

【０１８０】

［実施例３］

実施例１における穴付ミラー６１の設置角度（信号光１１０の光軸に対して４５度）を変更し、楕円状穴１６１の形状（短径に対する長径の長さ）を設置角度に基づいて三角関数を用いて計算して決定することによって、信号光１１０の光軸に対する光路切替の角度を、おおよそ５度から１７５度の範囲で自由に変更することができる。第２段目以降の穴付ミラー６２および６３の設置角度を同様に変更可能である。

【０１８１】

また、信号光１１０の光軸を回転軸として、穴付ミラー６１の設置位置を回転し、集光レンズ７１等の位置を移動することによっても、信号光１１０の光軸に対する光路切替の方向を、０から３６０度の範囲で自由に変更することができる。第２段目以降の穴付ミラー６２および６３の設置位置を同様に変更することもできる。

【０１８２】
［実施例４］
図５には、実施例４の光制御式光路切替型光信号伝送装置の概略構成が示されている。図５において信号光光源２０、制御光光源２１，２２，２３、ダイクロイックミラー５１，５２，５３，集光レンズ１０、光ファイバー１００、および、コリメートレンズ３０は実施例１の場合と同一である。
【０１８３】
図５の光制御式光路切替型光信号伝送装置は、実施例１の第２段目の光路切替機構９２に１つ、更に、第１段目の光路切替機構９１の後段に３つの光路切替機構を空間結合型で追加、連結し、合計７つの光路切替機構によって、また、３種類の制御光の同時点灯の組み合わせによって、信号光１２０の出射先を光ファイバー１０１，１０２，１０３，１０４，１３，１４，１５，および１６の８方向へ光路切替するものである。すなわち、原理的には一般に、ｎを２以上の整数として、ｎ種類の制御光の点灯状況の組み合わせによって、２のｎ乗方向の光路切替が、２のｎ乗引く１個の光路切替機構を連結することによって可能になる。実際には光路切替機構１段当たりの信号光の透過率の組み合わせによって、実用的な組み合わせ段数が決まる。光路切替機構で光路が切り替わらない「直進信号光」の透過率を８５％（信号強度として０．７ｄＢ減衰）、光路が切り替えられた「切替信号光」の減衰率を８０％（同１．０ｄＢ減衰）と仮定すると、全て直進した場合の総合透過率は６１．４％（同２．１ｄＢ減衰）、３段とも切り替えられた場合の総合透過率は５１．２％（同２．９ｄＢ減衰）である。表２に３種類の制御光１２１，１２２，１２３の同時点灯の組み合わせと信号光出射先をまとめて示す。
【０１８４】
【表２】

	制御光			信号光出射先
	121	122	123	
制御光の組合せ	off	off	off	101
	off	off	on	13
	off	on	off	14
	off	on	on	102
	on	on	off	104
	on	on	on	16
	on	off	off	15
	on	off	on	103

【０１８５】
第１段目の光路切替機構９１の熱レンズ形成素子としては、実施例１の場合と同様に波長５３２ｎｍの信号光１２１を吸収する色素〔１〕の溶液を充填した色素溶液充填式熱レンズ形成素子を用いた。波長透過率特性も実施例１の場合と同一とした。
【０１８６】
第２段目の光路切替機構９２（光路切替機構９１からの直進光１１１と空間的に結合）と９５（光路切替機構９１からの切替光２１１と空間的に結合）の熱レンズ形成素子としては、いずれの場合も、実施例１の場合と同様に波長６７０ｎｍの信号光１２２を吸収する色素〔２〕の溶液を充填した色素溶液充填式熱レンズ形成素子を用いた。波長透過率特性については後で説明する。
【０１８７】
第３段目の光路切替機構９３（光路切替機構９２からの直進光１１２と空間的に結合），９４（同９２からの切替光２１２と空間的に結合），９６（同９５からの切替光２１５と空間的に結合），９７（光路切替機構９５からの直進光１１５と空間的に結合）の熱レンズ形成素子としては、いずれの場合も、実施例１の場合と同様に波長８００ｎｍの信号

光１２３を吸収する色素〔３〕の溶液を充填した色素溶液充填式熱レンズ形成素子を用いた。波長透過率特性については後で説明する。

【０１８８】

ここで、前段の光路切替機構からの直進光と結合する後段の光路切替機構９２，９３，９７においては、実施例１における光路切替機構の場合と同様に、集光レンズ３１などによって信号光および制御光を図７（ａ）および図９の位置５に相当する位置、すなわち、熱レンズ素子の光吸収層膜の入射面に近い位置において焦点を結ぶように調整し、更に、穴付ミラー６１などの穴１６１などの大きさも、実施例１の場合と同一とした。このようにすることで、前段の光路切替機構からの直進光を効率良く、後段の光路切替機構で直進または切替することが可能になる。光路切替機構９２，９３，９７においては、各々の制御光の透過率が０．０ないし０．２％、信号光８５０ｍｎの透過率が８５ないし９９％になるよう調節した。

【０１８９】

一方、前段の光路切替機構からの光路切替光（リング状断面の光）と結合する後段の光路切替機構９４，９５，９６においては、実施例２における光路切替機構１９１の場合と同様に、集光レンズ３１などによって信号光および制御光を図７（ｂ）および図１０の位置６に相当する位置、すなわち、熱レンズ素子の光吸収層膜の出射面に近い位置において焦点を結ぶように調整し、更に、穴付ミラー６１などの穴１６１などの大きさも、実施例２の場合と同一とした。ただし、光路切替機構９４，９５，９６には、前段の光路切替機構から、光路が切り替えられたリング状の信号光２１２，２１１，２１５が各々空間結合されて、リング状のまま入射するため、光路切替機構１９１におけるビーム断面リング化レンズ群３２１（図２ｂ）は設けなかった。一方、収束直進信号光１１９のビーム径を拡大するためのビームエキスパンダー３３１（図２ｂ）は、光路切替機構９４，９５，９６の各々に設けた。

【０１９０】

このようにすることで、前段の光路切替機構からのリング状断面の光路切替光を効率良く、後段の光路切替機構で直進または切替することが可能になる。光路切替機構９４，９５，９６においては、各々の制御光の透過率が１．０ないし５．０％、信号光８５０ｎｍの透過率が８５ないし９９％になるよう調節した。

【０１９１】

第３段（最終段）の光路切替機構から出射する直進光１１３，１１４，１１６，１１７については、各々、集光レンズ４０１，４０２，４０３，４０４によって集光され、出射信号光光ファイバー１０１，１０２，１０３，１０４へ入射する。同じく出射する光路切替光２１３，２１４，２１６，２１７については、各々、集光レンズ７３，７４，７５，７６によって集光され、出射信号光光ファイバー１３，１４，１５，１６へ入射する。これら光ファイバーの仕様は、実施例１の場合と同様である。

【０１９２】

本実施例４の光制御式光路切替型光信号伝送装置において、第１ないし３段目の光路切替機構の光応答速度を実施例１の場合と同様にして測定したところ、同様な結果が得られた。

【０１９３】

本実施例４の光制御式光路切替型光信号伝送装置の耐久性を実施例１の場合と同様にして測定したところ、各光路切替機構とも、各々連続１万時間経過しても、信号光の強度振幅は減衰せず、高い耐久性を確認することができた。

【０１９４】

本実施例４の光制御式光路切替型光信号伝送装置の偏波依存性を検証するため、信号光および制御光に１枚の偏光素子を挿入し、偏光角を種々変化させる実験を行ったが、偏波依存性は全く認められなかった。

【０１９５】

本実施例４の光制御式光路切替型光信号伝送装置の８本の出射信号光間のクロストーク

特性を調べるため、表２に示す制御光点灯の組み合わせ８通りの各々の場合について、光ファイバー１３，１４，１５，１６，１０１，１０２，１０３，１０４からの出射光強度を比較したところ、目的とする出射光強度に対するモレ光（クロストーク）強度は１０００ないし８０００：１（－３０ないし３９ｄＢ）と微弱であった。

【０１９６】

［実施例５］

図６には、実施例５の光制御式光路切替型光信号伝送装置の概略構成が示されている。本実施例５は、実施例４の光制御式光路切替型光信号伝送装置における空間結合型光路切替機構９１，９２，９３，９４，９５，９６，９７（図２ａまたは図２ｂに相当する）を光ファイバー結合型光路切替機構９１０，９２０，９３０，９４０，９５０，９６０，９７０（全て図３に相当）に置き換えたものである。前記光ファイバー結合型光路切替機構の全てにおいて、実施例１における光路切替機構の場合と同様に、集光レンズ３１などによって信号光および制御光を図７（ａ）および図９の位置５に相当する位置、すなわち、熱レンズ素子の光吸収層膜の入射面に近い位置において焦点を結ぶように調整し、更に、穴付ミラー６１などの穴１６１などの大きさも、実施例１の場合と同一とした。また、前記光ファイバー結合型光路切替機構の全てにおいて、熱レンズ形成素子の構成、材料、および、透過率特性は実施例１の場合と同一とした。個々の光ファイバー結合型光路切替機構を接続する光ファイバーの長さは、一般家庭内、病院内、オフィス内などの用途を想定し、１０ないし１００ｍとした。

【０１９７】

光ファイバー結合に基づく制御光のロスを補うために制御光光源２１，２２，２３の出力を高めることによって、全段の光路切替機構において、熱レンズ形成素子に入射する制御光のパワーが２ないし５ｍＷになるよう調整した。また、信号光光源の出力も、８つの出射信号光が各々充分なパワーになるよう調節した。

【０１９８】

第３段目の光路切替機構９３０、９４０，９６０，９７０の直進出射信号光は、光ファイバーとコリメートレンズを経由して各々受光器１０１３，１０１４，１０１６，１０１７へ入射させ、光路切替された信号光は、光ファイバーとコリメートレンズを経由して各々受光器２０１３，２０１４，２０１６，２０１７へ入射させた。

【０１９９】

表３に本実施例５における３種類の制御光１２１，１２２，１２３の同時点灯の組み合わせと信号光出射先受光器の対応関係をまとめて示す。

【０２００】

【表３】

	制御光			信号光出射先
	121	122	123	
制御光の組合せ	off	off	off	1013
	off	off	on	2013
	off	on	off	1014
	off	on	on	2014
	on	on	off	1016
	on	on	on	2016
	on	off	off	1017
	on	off	on	2017

【０２０１】

本実施例５の光制御式光路切替型光信号伝送装置の光応答速度、耐久性、偏波依存性、および、クロストークについて実施例４の場合と同様に測定し、同等ないし同等以上の結果を得た。

【産業上の利用可能性】

【０２０２】

光制御式光路切替型光信号伝送装置および光信号光路切替方法は、例えば、企業のオフィス、工場、病院、一般家庭などにおいて、高精細画像データおよび高精細動画データなどの大容量デジタル情報を、サーバーから複数のクライアントの特定の１箇所へ、高速に配信するシステムにおいて好適に使用される。

【図面の簡単な説明】

【０２０３】

【図１ａ】実施例１の光路切替機構を省略せずに表記した光制御式光路切替型光信号伝送装置の概略構成図である。

【図１ｂ】実施例１の光路切替機構を記号化して簡略表記した光制御式光路切替型光信号伝送装置の概略構成図である。

【図２ａ】空間結合型の光路切替機構の概略構成図を記号化して簡略表記することを示した図である。

【図２ｂ】空間結合型の光路切替機構の概略構成図を記号化して簡略表記することを示した図である。

【図３】光ファイバー結合型の光路切替機構の概略構成図を記号化して簡略表記することを示した図である。

【図４】実施例２の光制御式光路切替型光信号伝送装置の概略構成図を記号化して簡略表示した図である。

【図５】実施例４の光制御式光路切替型光信号伝送装置の概略構成図を記号化して簡略表示した図である。

【図６】実施例５の光制御式光路切替型光信号伝送装置の概略構成図を記号化して簡略表示した図である。

【図７】熱レンズが形成されない場合の光の進み方を示した図である。

【図８】ビームウエストの位置を光吸収層膜のビーム入射側近傍（ａ）または出射側近傍（ｂ）に調整した場合において熱レンズが形成された場合の光の進み方を示した図である。

【図９】ビームウエストの位置を光吸収層膜のビーム入射側近傍に調整した場合における光路切替の原理を示した模式図である。

【図１０】ビームウエストの位置を光吸収層膜のビーム出射側近傍に調整した場合における光路切替の原理を示した模式図である。

【図１１】熱レンズ形成素子の構成例を例示した断面図である。

【図１２】熱レンズ形成素子の構成例を例示した断面図である。

【図１３】信号光ビーム断面の光強度分布測定に用いたスリットと光ビームとの関係を示す図である。

【図１４】集光レンズなどで収束されたガウスビームの焦点近傍における様子を表した模式図である。

【図１５】オシロスコープで観察した制御光および信号光の波形を表した図である。

【図１６】オシロスコープで観察した制御光および信号光の波形を表した図である。

【図１７】制御光を断続する周波数と光路切替された信号光の強度（振幅）の関係を表した図である。

【図１８】信号光のビーム断面の光強度分布を表した図である。

【図１９】信号光のビーム断面の光強度分布を表した図である。

【図２０】信号光のビーム断面の光強度分布を表した図である。

【図２１】色素溶液充填式熱レンズ形成素子を例示した模式図である。

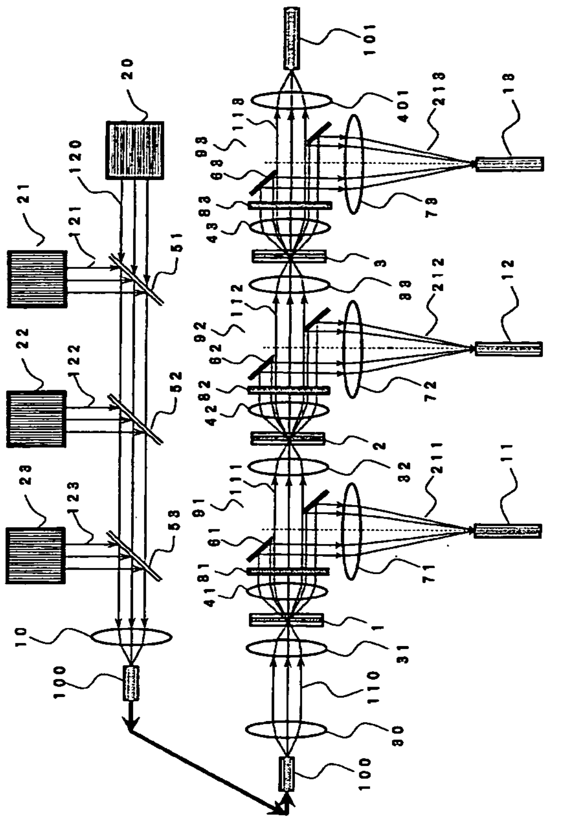
【図２２】色素〔１〕、〔２〕および〔３〕の溶液の透過率スペクトルを各々実線、鎖線および一点鎖線で表した図である。

【符号の説明】

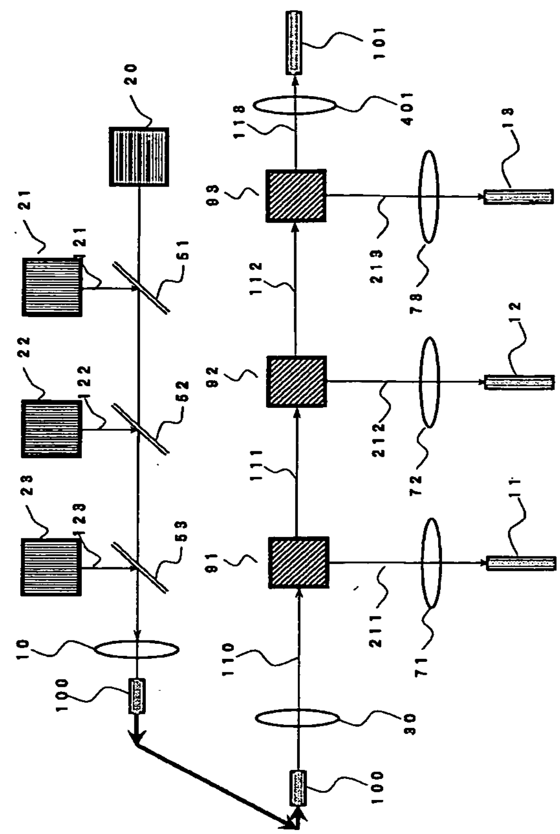
【０２０４】

１，２，３　熱レンズ形成素子、５，６　ビームウエスト（焦光点）、１０　信号光および制御光を光ファイバーへ入射させるための集光レンズ、１１，１２，１３，１４，１５，１６　出射信号光の光ファイバー、２０　信号光光源、２１，２２，２３　制御光光源、３０　コリメートレンズ、３１，３２，３３　集光レンズ、４１，４２，４３　受光レンズ、５０　入射側熱レンズ、５１，５２，５３　ダイクロイックミラー、６０　出射側熱レンズ、６１，６２，６３　穴付ミラー、７１，７２，７３，７４，７５，７６　リング状出射信号光用集光レンズ、８１，８２，８３　波長選択透過フィルター、９１，９２，９３，９４，９５，９６，９７　空間結合型光路切替機構、１００　信号光および制御光伝送のための光ファイバー、１０１，１０２，１０３，１０４　出射信号光の光ファイバー、１１０　コリメートされた入射信号光および入射制御光、１１１，１１２，１１３，１１４，１１５，１１６，１１７　直進信号光、１１８　漏れ信号光、１１９　収束直進信号光、１２０　信号光、１２１，１２２，１２３　制御光、１６１　穴付ミラーの穴、１９１　空間結合型光路切替機構、２００　通常の開き角度の出射信号光、２０１　リング状に拡がる出射信号光、２１１，２１２，２１３，２１４，２１５，２１６，２１７　光路切替後の出射信号光、３００　波面、３０１　焦点（集光点）、３１０　直進出射信号光の集光レンズ、３１１　コリメートレンズ、３２１　ビーム断面リング化レンズ群、３３１　ビームエキスパンダー、４０１，４０２，４０３，４０４　直進出射信号光の集光レンズ、５００　熱レンズ形成素子、５０１　伝熱層膜、５０２　伝熱層膜、５０３　光吸収膜、５０４　光吸収膜、５０５　熱レンズ形成層、５０６　光透過層、５０７　屈折率分布型レンズ、５０８　信号光、５０９　制御光、６００　熱レンズ形成素子、６０１　伝熱層膜、６０２　伝熱層膜、６０３　光吸収膜、６０４　光吸収膜、６０５　熱レンズ形成層、６０８　信号光、６０９　制御光、６１０　集光レンズ、７００　光強度分布測定器、７０１　受光部、７０２　第一のスリット、７０３　第二のスリット、７１０　点、７１１　コリメートレンズ、７２０　点、８００　色素溶液充填式熱レンズ形成素子、８０１，８０２　入射・出射面ガラス、８０３，８０４　側面ガラス、８０５　底面ガラス、８０６　導入管、８０７　導入口、８０８　色素溶液充填部、８０９　光学セル、９１０，９２０，９３０，９４０，９５０，９６０，９７０　光ファイバー結合系を含む光路切替機構、１００１　伝熱層膜、１００２　光吸収層膜、１００３　伝熱層膜、１０１３，１０１４，１０１６，１０１７　受光器、１１１０，１１２０，１１３０，１１４０，１１５０，１１６０，１１７０　コリメートされた光ファイバー出射光、１２１０　制御光の波形、１２２０　信号光の波形、２０１３，２０１４，２０１６，２０１７　受光器、２１１０，２１２０，２１３０，２１４０，２１５０，２１６０，２１７０　コリメートされた光ファイバー出射光。

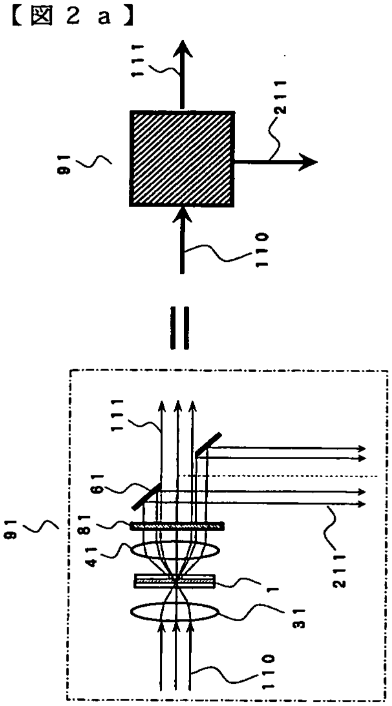
【図１ａ】



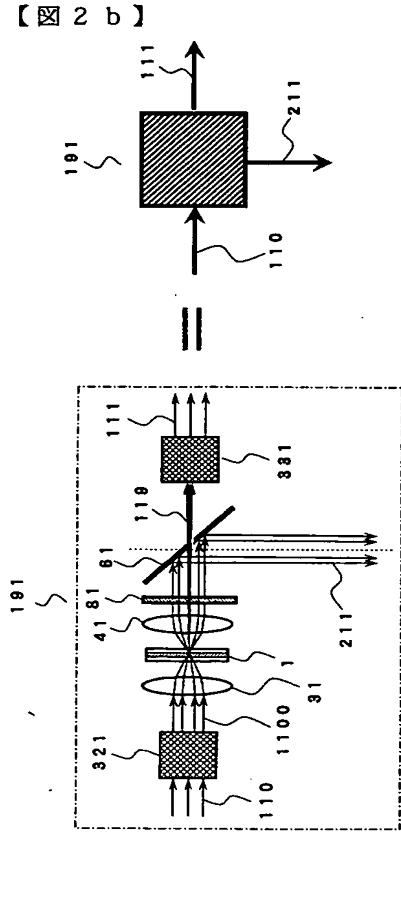
【図１ｂ】



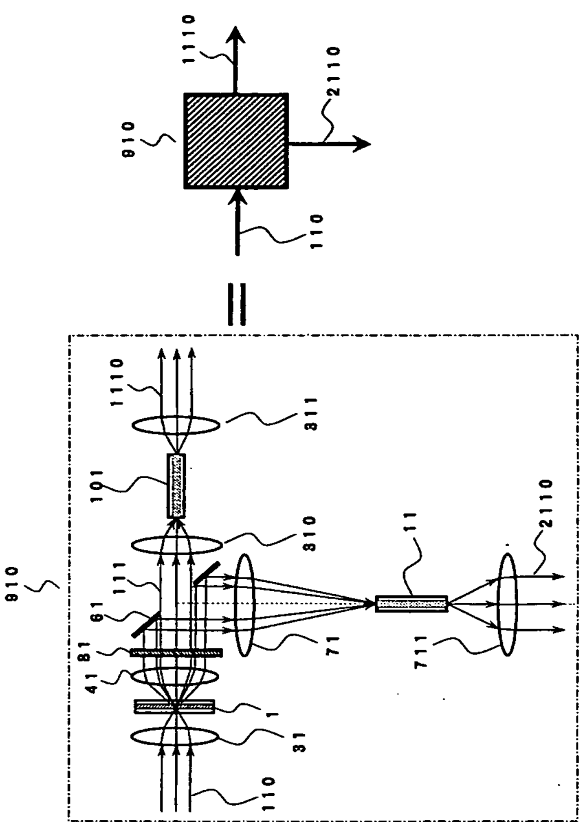
【図２ａ】



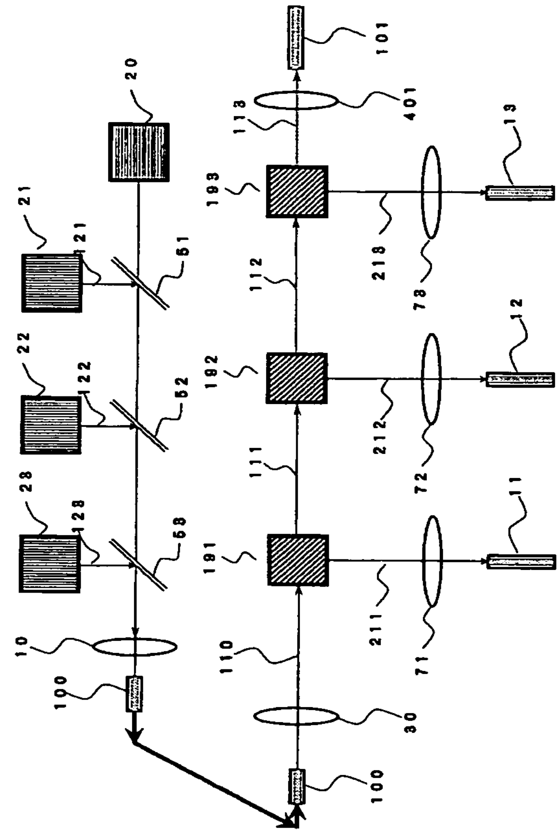
【図２ｂ】



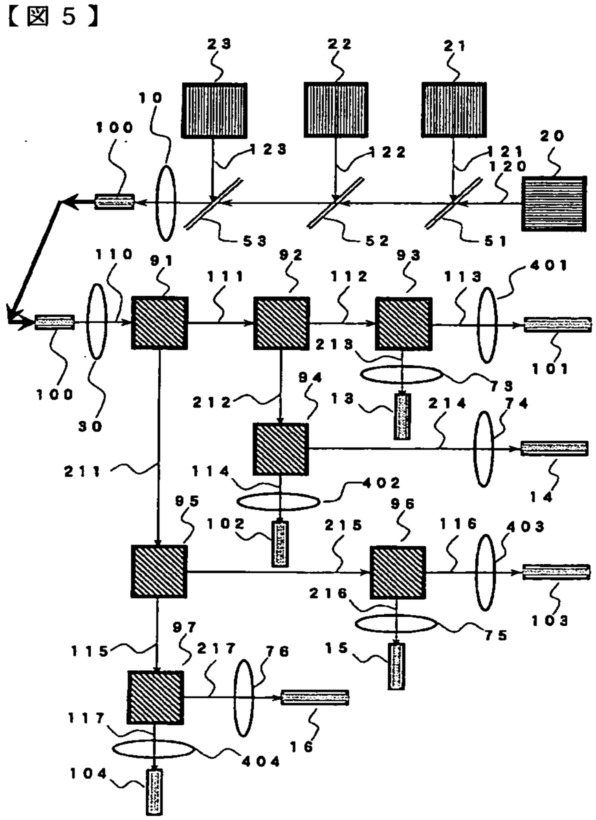
【図３】


1110
2110
910
110
1110
311
101
310
111
2110
11
910
61
81
41
71
711
1
31
110

【図４】


101
20
401
113
13
193
21
121
51
213
112
73
22
122
52
192
12
212
72
23
123
53
111
191
11
211
71
10
110
100
30
100

【図５】


23
22
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100
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121
120
20
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52
51
110
91
111
92
112
93
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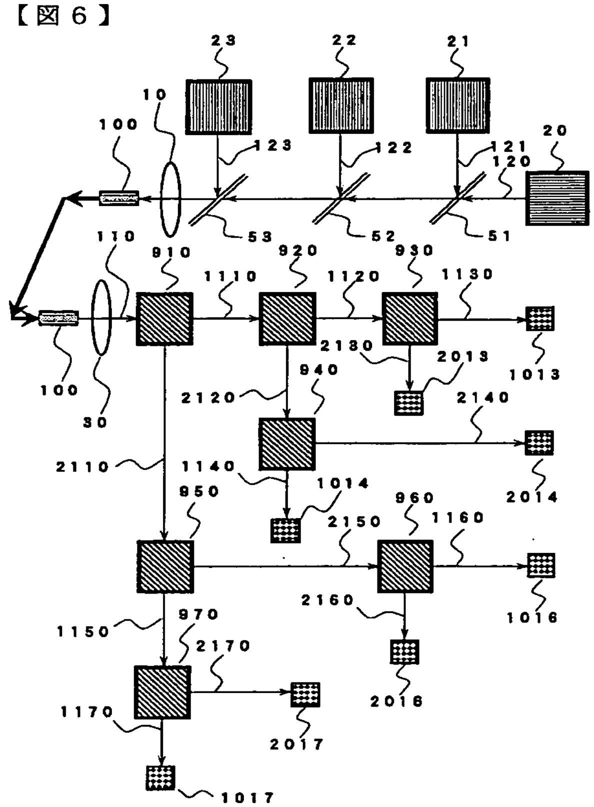
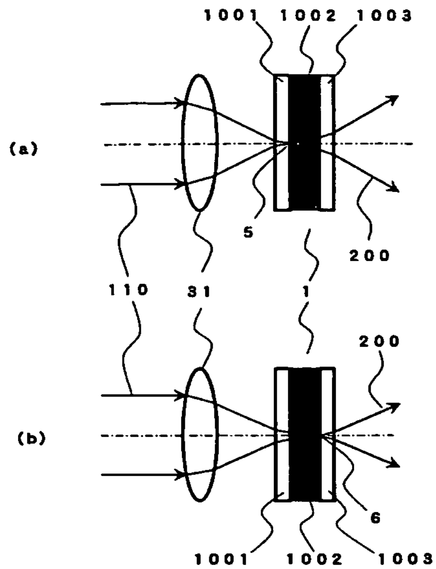
401
101
100
30
213
73
212
94
13
214
74
211
114
14
402
95
102
215
96
116
403
103
216
75
115
97
217
76
15
117
16
404
104

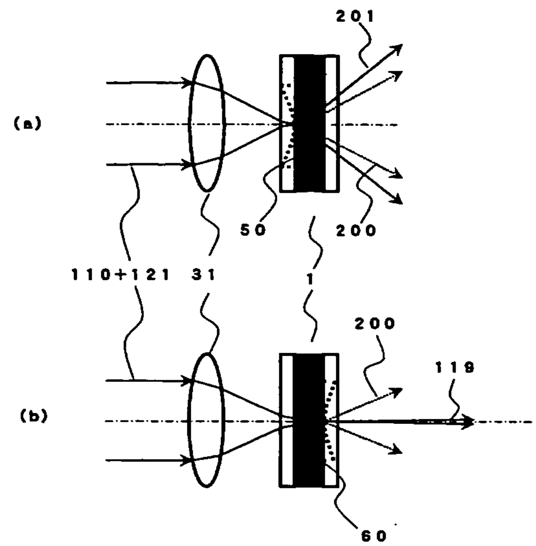
【図６】


23
22
21
10
100
123
122
121
120
20
53
52
51
110
910
1110
920
1120
930
1130
1013
100
30
2130
2013
2120
940
2140
2110
1140
1014
2014
950
2150
960
1160
1016
2160
1150
970
2170
2016
1170
2017
1017

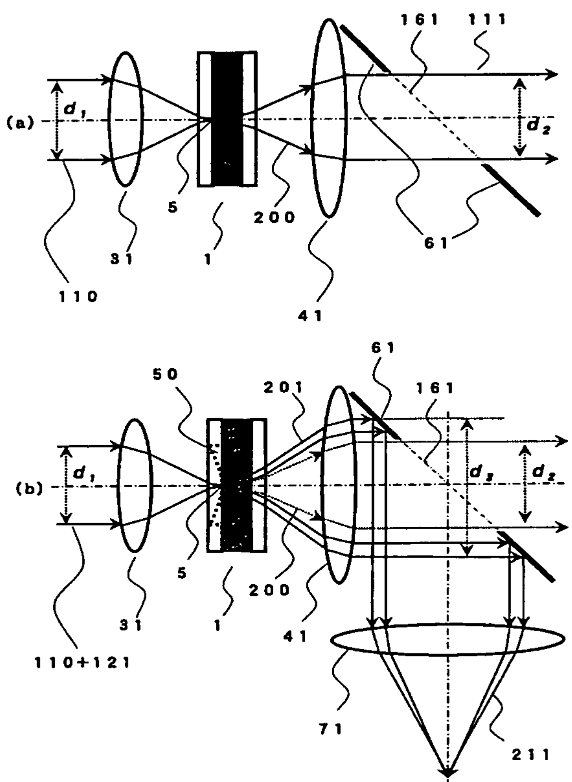
【図７】


1001
1002
1003
(a)
5
1
200
110
31
1
200
(b)
6
1001
1002
1003

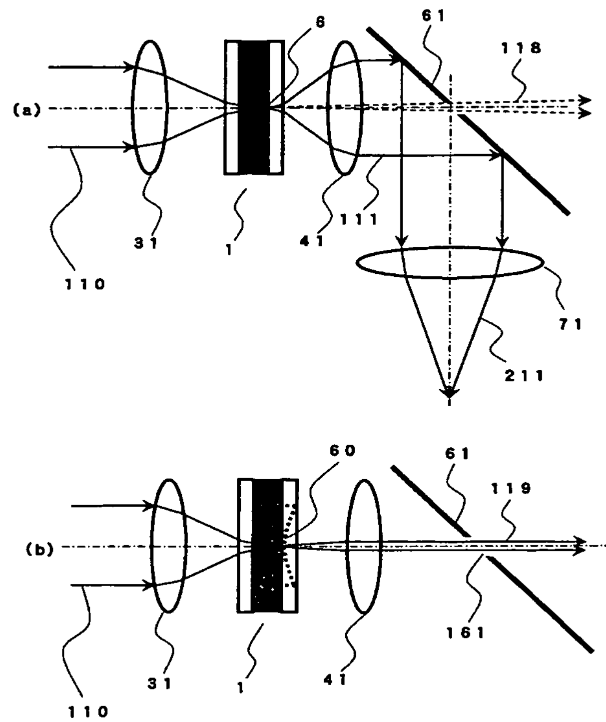
【図８】


201
(a)
50
200
110+121
31
1
200
119
(b)
60

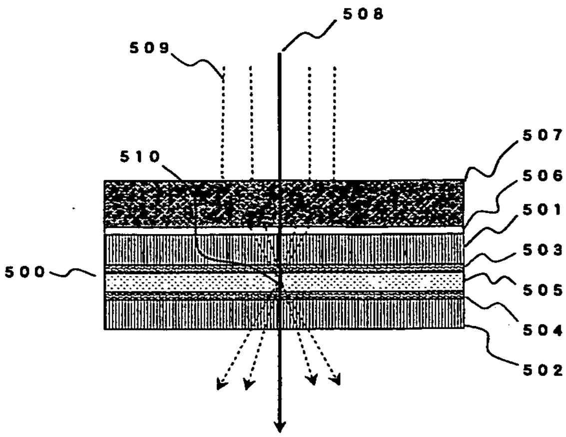
【図９】


161
111
(a)
d_1
d_2
5
200
61
31
1
110
41
61
50
201
161
(b)
d_1
d_3
d_2
5
200
31
1
41
110+121
71
211

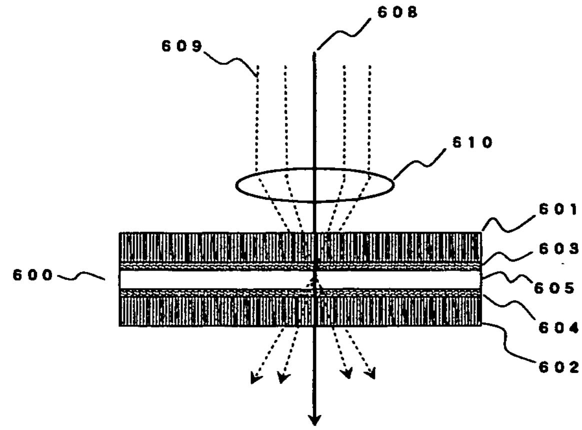
【図１０】


6
61
118
(a)
111
31
1
41
110
71
211
60
61
119
(b)
161
31
1
41
110

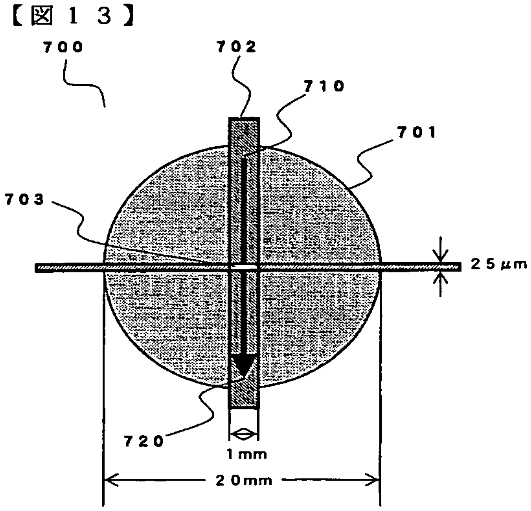
【図１１】



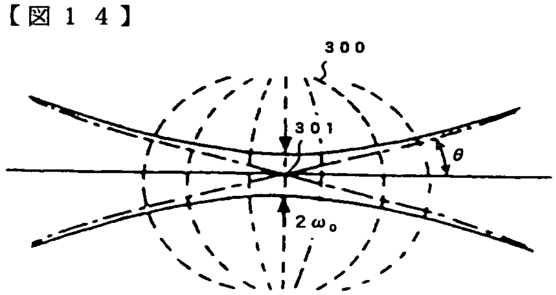
【図１２】



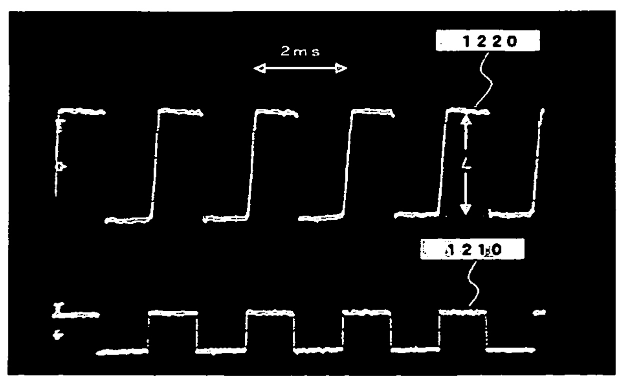
【図１３】



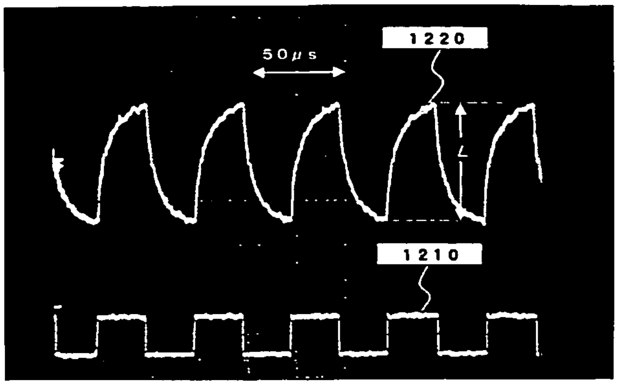
【図１４】



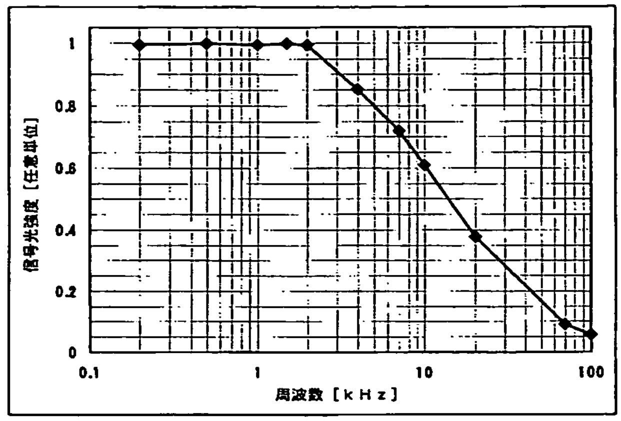
【図１５】



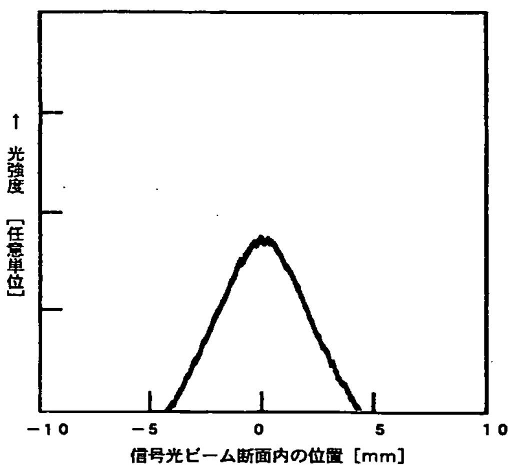
【図１６】



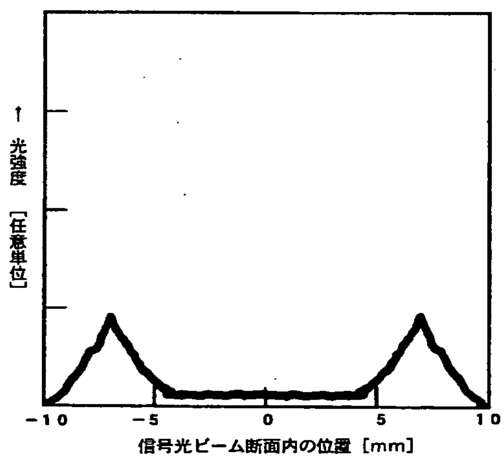
【図１７】



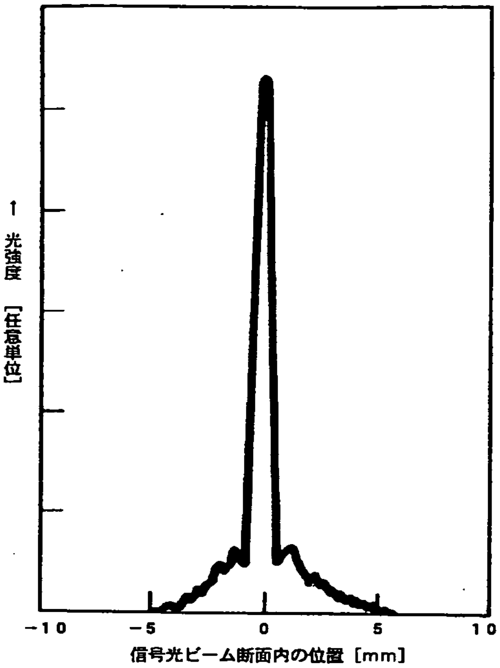
【図１８】



【図１９】

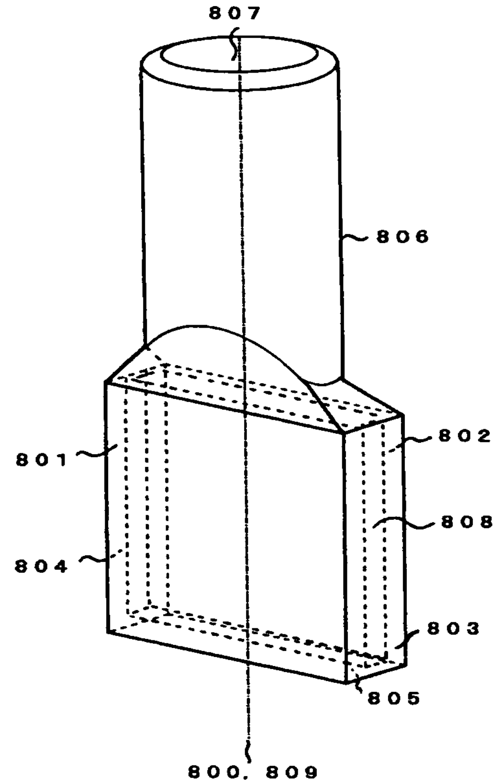


【図２０】



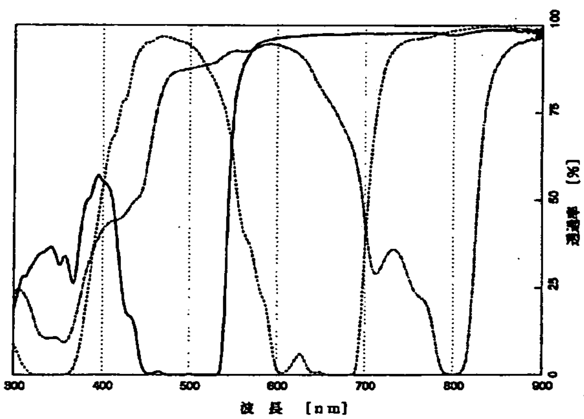
↑ 光強度 [任意単位]
−10
−5
0
5
10
信号光ビーム断面内の位置 [mm]

【図２１】



807
806
801
802
808
804
803
805
800, 809

【図２２】



300
400
500
600
700
800
900
波長 [nm]
0
25
50
75
100
透過率 [%]

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